DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

SEPTEMBER 1960

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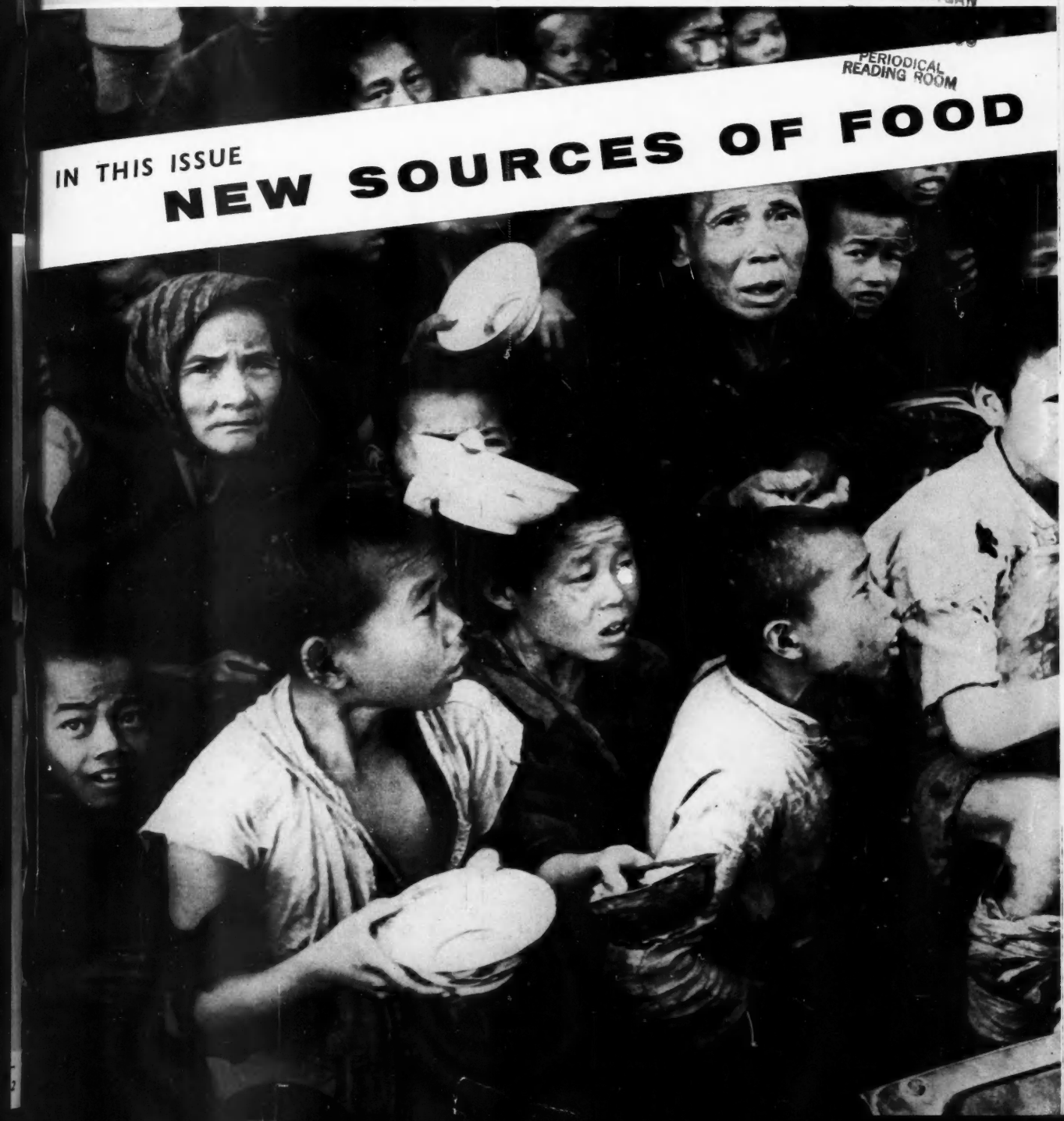

PERIODICAL READING ROOM

IN THIS ISSUE

NEW SOURCES OF FOOD

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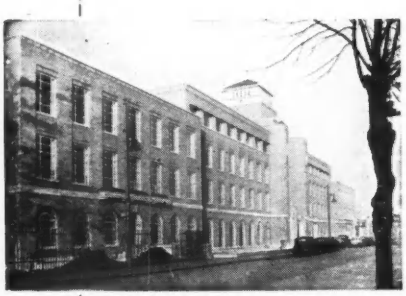

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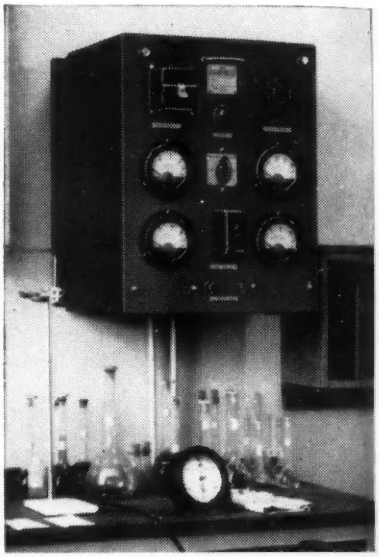

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DISCOVERY

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S. Edward Gamarekian

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OUR COVER PICTURE

It is estimated that the world's population will have doubled by the turn of the century. This means that another 3000 million people will have to be fed.

(*United Nations*)

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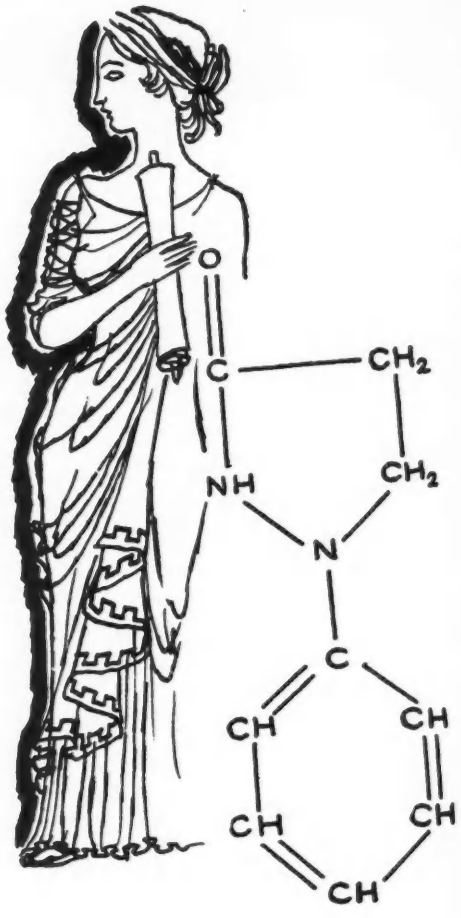
CHANGE OF EDITORSHIP

As from this issue, DISCOVERY is edited by S. Edward Gamarekian, a research and development engineer and university lecturer who was recently the science correspondent for the *Washington Post* of Washington, D.C., U.S.A. Dr Anthony R. Michaelis, who has been Editor for the last four years, has now taken up the position of Director of Information for the CIBA Group of companies.

Art by the grace of Science



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THE PROGRESS OF SCIENCE

WORLD'S POPULATION

The world's population doubled during the first sixteen centuries after the birth of Christ. Since then it has grown with increasing rapidity. According to the best estimates, it doubled in the next two centuries from 1600 to 1800, then doubled again in the next hundred years, and once more from 1900 to 1960. So there are now about fifteen times as many people in the world as there were at the beginning of the Christian era. At the present rate of increase, the existing population of just over 3000 million will be about 6000 million by the end of the 20th century.

This phenomenal rate of increase in the last 300 years has not been the same in all parts of the world. The population of Europe increased about sixfold from 1650 to 1950, but that of Africa increased only twofold during the same period, and was, in fact, almost stationary until 1900.

Today, the greatest increases in population are mostly in the under-developed countries of Asia and Africa, whilst in most of the developed countries the increase is much smaller. If the very recent estimates from China are correct, its population of about 650 million will have reached 1000 million—one-third of the total present population of the world —in about fifteen years' time.

The population growth in each area is dramatic evidence of the interplay between advances in public health and medicine on the one hand and the adoption of birth-control measures on the other.

In Europe until a few hundred years ago, and in Africa and parts of Asia until quite recently, there was a high birth-rate but a comparable death-rate; the population hardly changed. In Europe the number of deaths dropped gradually, with no change in births at first. Population grew rapidly, and this growth only began to slow down when, a hundred years or so after the beginning of death control, people began to practise birth control. Today, all those advances which lowered the death-rate in Europe over a period of centuries are being concentrated into a few decades in the under-developed countries, but birth control is coming relatively slowly and no change is envisaged until a simpler and cheaper means of birth control is found.

The whole question of food and population is regarded by many as being the most serious of our day. The British Association, at its meeting this year in Cardiff, is for the first time holding a plenary session in order to discuss the problem. One fact emerges from these articles and discussions, and from all that has been said and written about the abolition of hunger. This is that there is no single solution, no panacea. The problem will not be solved by attempting to turn all of us into vegetarians, or by producing algae in culture, or by developing an oral contraceptive, or by synthesising sugar in the laboratory, or by finding a new way to improve the soil. All of these things, and very many more, must be done simultaneously. What is wanted is a wide concept of the word nutrition—the feeding of people.

At the present time, food supplies are actually increasing faster than the world population, but there is a problem of distribution. Despite world surpluses, there is more hunger in large parts of Latin America, Africa, and South-east Asia than ever before. The sole enduring avenue for progress is unquestionably that of increased agricultural production by the deficit areas themselves, both through the cultivation of unused land and the more effective exploitation of land already in use. Herein lies an immense challenge to scientific ingenuity. Soil development and irrigation, plant-breeding and seed improvement, measures against pests and disease, livestock improvement, fish-farming, and even more radical techniques in food processing and synthesis constitute a programme for action by scientists to help the under-developed countries of the world.

But what of the dilemma at home? Does Britain need to aim at a greater home agricultural output. What part can science play? Although British agriculture is intensive and efficient, the opportunities for science are still considerable. Provision must also be made for increased nutritional standards. The organising of agriculture on purely mass-production lines could have major social effects. This year's report of the Agricultural Research Council assumes special importance since it records the effective completion of the 1946 post-war expansion plan for agricultural research. There are still, however, important *lacunae* which the authorities are trying to remedy—the comparative weakness until recently on the scientific side of pig- and hen-farming, the serious neglect of many aspects of meat production, and the absence of any programme for farm buildings. On the commercial side there is a gap to be made up in the quality of our seeds.

Whatever the scope for research, there remains one further fact of paramount importance. For scientific investment in agriculture to be fruitful, it must be matched by receptivity at the production end among farmers and farm-workers. This means much more than merely expanding the advisory services, important though these are. It means welding, through propaganda, education, and training, the practising farmer and the scientist into a harmonious and long-lasting partnership.

$4 MILLION FOR DESERT LOCUST CONTROL

The six-year desert locust control programme now starting under the United Nations Special Fund marks a new departure in international science. This is the first time a project involving the co-operation of several United Nations specialised agencies as well as some twenty governments has included really large commitments on original research as an integral part of the plan of operations.

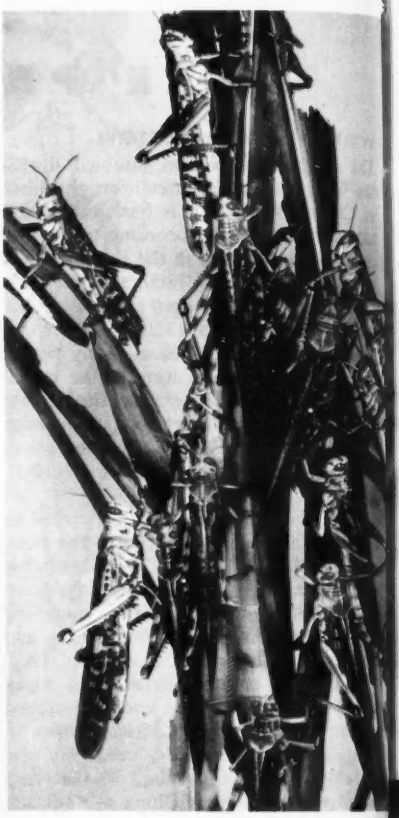
No less than 70% of the $3,865,800 budget is devoted to basic studies. At the top of the list is $1·4 million for Operational Research; $720,000 is budgeted for field research stations, and $567,000 for the continuation of an ecological survey already under way. This last project, now in operation for some two years, is beginning to show results. The survey is aimed at finding out what, if any, are the common features of those areas in which desert locusts most regularly breed. Unlike other plague locusts, the desert locust *Schistocerca gregaria* does not have fixed breeding grounds from which swarms emanate.

Studies of the south-western Sahara and Chad-Sudan-Ethiopia region show that the breeding of swarms is most often associated with outstanding geographical features located in otherwise very uniform, featureless belts of desert or semi-desert. Each site offers a diversity of ecological conditions and, hence, a wide selection of habitats. Another common feature suggested by other investigators and now confirmed is that the settling of breeding swarms occurs more often in areas where two contrasting types of vegetation occur.

What conclusions can be drawn from

these observations are not yet clear but it appears at last that some pattern is emerging. It now seems clear that high-frequency breeding of the *Schistocerca* is characterised not by a specific type of habitat (as is the case with such species as the red and migratory locusts), but by areas of pronounced relief that present a mosaic pattern of vegetation and soil conditions. This single finding is of the greatest importance since the increased use of land for food production may increase the very conditions that best suit man's most powerful rival in crop consumption!

With the new United Nations programme, the fight against the desert locust will move from the defensive to the offensive. A study is now being made of the cost of a concentrated air and ground attack in a localised seasonal high-frequency swarm concentration and breeding area, preferably during a period of plague recession. It is in the last few words that the importance of this plan lies. During periods of plague recession, it has always been almost impossible to persuade the governments of countries that have suffered severe locust damage to continue their control programmes. Yet the greatest gains may be made during just such periods. With this new programme under international control, we should see dramatic strides made.



Locusts clustered on maize stalk.

Before an attack—orange trees in the Souss Valley.

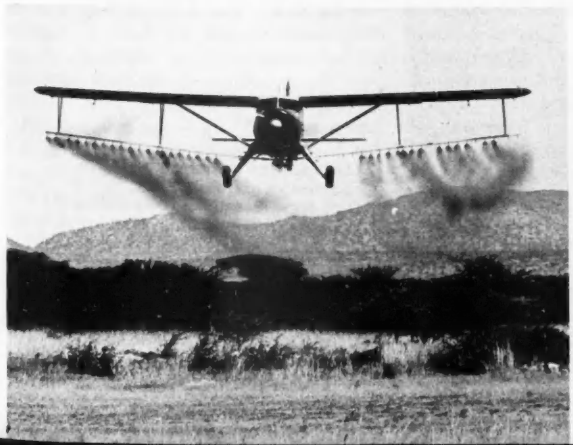
The aftermath—complete devastation.

(*Above*) Swarm of locusts invading 400-square-mile area in Ethiopia.

(*Left*) Portable sprayer used in some parts of the Middle East in the anti-locust campaign.
(By courtesy of Shell)

(*Below, left*) Aircraft spraying against desert locust swarms has been undertaken in Borama, Somaliland, since 1955, using concentrated oil solutions of insecticide.
(Photo by C. Rennie)

(*Below*) A line of bait (poisoned bran) has been thrown down in front of a marching band of hoppers in Somaliland. They do not advance over the bait, but stop to eat it, becoming more and more crowded as ever-increasing numbers reach the line. Only when every scrap of bait is covered by the first-comers will the following hoppers pass over it; and for these another line will have been laid a little way ahead.



FREEDOM FROM HUNGER

(*Left*) Successful demonstrations dispel the mistrust of Siamese farmers who soon flock to Pak Chong to have their buffaloes vaccinated against rinderpest. (*United Nations*)

(*Left, centre*) Wheat in the desert—a new field in an arid area near Mastung, in Baluchistan.

(*Below*) Students examine pollen and study growth of rice plants in nine-nation FAO project to improve yields. New types will give greater yields, close food gap.

(*Left*) Ceylon fishermen, trying to increase yield from the sea, haul in their seine nets under the watchful eye of an FAO expert.

AN FAO REPORT ON AFRICA

While few are actually starving in Africa, there is abundant evidence of defects in African diets which affect the health of the population. Nutritional surveys by the Food and Agricultural Organisation of the United Nations show that carbohydrate foods generally provide three-quarters of the calories and may reach as high as 90% of the diet.

In newly developing countries, as found in Africa, the quest for better nutrition is involved with social, economic, and technical factors. An African mother will wean her child at the age of eighteen months and then place it on the same starchy diet that she herself consumes. As a result, roughly 30% of the children born alive die before the age of five. Among certain tribes the mortality-rate in this age-group has been as high as 60%, and in many parts of Africa parents expect one child out of two to die before reaching its fifth birthday.

Protein malnutrition in children can lead to kwashiokor—a disease marked by retarded growth, mental apathy, fibrosis of the liver, and heavy mortality in the absence of proper treatment. Anaemia, vitaminosis, riboflavinosis also often occur in children because they lack the appropriate vitamins and minerals in their diets after weaning.

Food habits tend to keep protein out of the African diet. In most parts of Africa, meat is rarely consumed, even where cattle and goats are numerous. Owners consider the beasts to be capital. As a result, excepting festivals and celebrations, cattle are eaten only when they die of old age or of disease. Chicken and eggs are reserved mainly for gifts, and game is becoming scarce.

Butter is often used as an ointment or cosmetic and seldom occurs in the diet. Milk is so little valued that certain pastoral tribes in the north of Uganda live on millet and root crops and give away the milk to their herdsmen. In the towns and a few other areas, however, milk is appreciated, but it is too expensive for all but the most privileged Africans.

Fish, a cheaper and excellent source of animal protein, is much liked by the African in dried, smoked, or salted form but is generally too expensive for the average consumer.

While food taboos that infiltrate the African's diet are tending to disappear, they still forbid the consumption of animal protein by the most vulnerable groups of the population—pregnant women, nursing mothers, and young children.

The range of crops that could be grown in the equatorial forest is very limited, while in the drier parts of Africa the short growing-season confines cultivation to millet and sorghums. A wider range of crops could be planted, but, through ignorance and the high yield coming from starchy crops, the African tends to stay with the high-calorie, low-protein starchy staples. Cassava, for instance, is highly regarded as a famine reserve, for it can be stored in the soil for some time and is immune to locust damage. Cultivation of the crops usually falls to the women who, with their other work, do not find time to grow enough of lower-yielding crops such as vegetables and legumes.

When cash crops, such as cocoa, cotton, or peanuts, replace the traditional food crop of an area, or when a family takes up wage employment, the African tends to buy prestige foods, such as white bread and sugar, rather than add the needed protein to his diet. The money earned by the rural farmers is often considered "extra" and is spent for more cattle, another wife, or clothes, and jewels to be placed on the wall—not better nutrition.

Fish production, which is increasing in Africa, could provide an excellent supply of protein-rich food, but there are many problems to overcome in the provision of marketing and other facilities, equipment, technical training, and research. The dried-fish trade is becoming particularly important, especially in the region south of the Sahara, where the Congo and Nigeria are now importing over 20,000 tons of dried-fish products annually.

Cultural patterns and beliefs as well as primitive methods of agriculture have a determined effect on food production, but these may be changed by education. In fact, all programmes to improve nutrition, whether immediate or long range, hinge upon education.

FAO has assisted a number of governments in introducing the teaching of nutrition into the school system. This, coupled with school feeding, school gardens, and poultry-raising in the primary schools, and agriculture and home economics extension services should result in better nutrition of the next generation.

Recently, FAO has become interested in campaigns to promote consumption of specific foods. For example, by using mass media, combined with work in communities and schools, fish consumption has been trebled within a few months in two pilot areas in Morocco. Similar programmes are now starting to encourage the consumption of groundnut and oil-seed products.

Supplementary feeding programmes have been organised with the United Nations Children's Emergency Fund (UNICEF) in the Congo, Ruanda-Urundi, Morocco, Tunisia, Senegal and Soudan, Ivory Coast, Kenya, Uganda, Tanganyika, Togo, Nigeria, and other countries. These programmes distribute dried skim-milk and other foods through schools and maternal and child health and social centres.

The use of certain protein-rich foods, such as press-cakes of groundnuts and fish flour, is being investigated in Morocco, the Congo, Nigeria, Senegal and Uganda, the Republic of Togo, Angola, and the Cameroons. A fish-flour plant, built by private industry with assistance from FAO in Morocco, produces a ton of flour a day for use in child-feeding programmes. Non-traditional fish-products are being produced and tried in Tunisia, aiming at replacing imported skim-milk in the feeding programmes. A groundnut-flour factory that can produce ten tons a day of a highly nutritive product has had its produce approved for sale and development in West Africa by an international committee. Recently, an FAO expert prepared plans for a biscuit factory in Uganda, the flour being made of local maize and groundnuts.

One of the pilot action projects approved for FAO's recently launched Freedom-from-Hunger Campaign, and supported by the Committee of German Bishops, who are providing the funds, is to grow grain legumes. This project is another way of combating protein malnutrition in Africa.

However, in developing food policies, governments need more adequate data on food production and consumption. This includes agricultural production statistics, dietary surveys and inquiries on family expenditure on food, and studies on the relation between diet and health and the incidence of malnutrition and deficiency diseases. Many such investigations have been made but more are needed.

National nutrition committees already established in the Union of South Africa, northern, western, and eastern Nigeria, Angola, Cape Verde Islands, Senegal and Soudan, Ghana, and the Cameroons, can make a valuable contribution to the solving of nutrition problems in Africa.

FAO and the World Health Organisation (WHO) have organised courses to train personnel in nutrition. So far, some training has been given to about a hundred workers in countries and territories in Africa south of the Sahara. The trainees have reinforced existing services in the Congo, Togo, Senegal and Soudan, and Uganda and have helped to create new nutrition services in the Ivory Coast, Ghana, Cameroons, Madagascar, and the Portuguese territories.

[continued on page 410]

NEW SOURCES OF FOOD

N. W. PIRIE

Rothamsted Experimental Station, Harpenden

Eliminating wastefulness and increasing the yield from traditional sources of food will diminish the problem of feeding the world's growing population. But present and foreseeable needs are so great that every reasonable new source must also be exploited.

In 1951 we gave the title "Four Thousand Million Mouths" to a book of essays explaining how various aspects of existing knowledge could be used to meet the needs of the world's population, as we foresaw it, "within the lifetime of some of our children". Many reviewers of that book scoffed at it as alarmist and said that the usual laws would operate and stabilise the population at a much lower figure. The facts have proved the contrary and conservative official estimates now suggest that we may reach 4000 million in twenty to thirty years. Furthermore, mainly through the sustained and vigorous efforts of FAO, there is general recognition of the inadequacy of present-day food supplies; half the people in the world are now underfed. Although world food production by the end of this century is likely to be more ample than it is today—perhaps three times the bulk and of improved quality—present and foreseeable needs are so great that every reasonable source should be tapped.

Two factors may diminish the world's need for food. War between powerful nations, with nuclear or biological weapons, would kill a large part of the population. The immediate result would probably be famine because communications would collapse and crops would be destroyed, but it is conceivable that after this phase there would be a period resembling to some extent the 18th century, with abundant nearly empty land waiting for development. Few will be foolish enough to use this as a justification for modern weapons. The second factor—contraception—introduces an immense uncertainty into any forecast of world population. It seems fairly safe to assume that when concupiscence can be dissociated from fecundity the birth-rate will fall, but it is not absolutely certain. If large families are wanted, for their own sake, our job is to try to feed them rather than to say that families must be limited because we cannot be bothered to produce the necessary food. If, on the other hand, people prefer small families and more space, it is our job to do the necessary research to ensure that the consequences of sexual activity are not in doubt. A third factor tending to upset predictions about population is sometimes mentioned—but probably only as a joke. This is that people may start living in artificial satellites or on other planets. They may, but the probability that any significant number will be doing this in the time for which useful predictions can be made is negligible. So, bearing all these factors in mind, the prudent course is to make plans for abundant food.

Food supplies can be increased in three ways: we can do more skilfully or more vigorously something we are already doing; various forms of waste can be avoided; radically new sources and techniques can be introduced. These approaches to the problem are complementary and not always clearly distinguishable from one another, but the classification is convenient and the possibilities will be considered in that order.

WASTED SUNSHINE

Photosynthesis is the primary source of our food, and agriculture is a technique for increasing its effectiveness. The process depends on sunlight and there is little prospect of doing anything to increase or control that. But we can increase the area over which sunlight is used and the proportion of the year for which it is used. These are the two factors that have been mainly responsible for making food available for the expansion in population during the past few centuries; they are now nearing their limit and not much virgin land remains that can be brought into cultivation by conventional means. There is, however, still scope in those parts of the world subject to wide temperature variations (so inaptly called the Temperate Zone) for improving frost-hardy varieties of plants so that more of the spring sunshine may be used. Farmers do not sufficiently clearly realise that any illuminated surface without a complete green cover is wasting its time.

The tropical rain forests are the most extensive underexploited areas still remaining, but they are generally written off as unproductive. That only means that they are not suited to conventional crops farmed by methods that are best described as "agricultural mining" and that not enough work has been done on finding uses for the type of plant that grows, or could grow, there exuberantly. As in the highly productive areas of Europe, productivity can only be maintained by a generous use of fertilisers. If we take nutrients steadily out of a piece of land, we must put them back wherever the land is, and, as our need increases, this will be done. Given water, warmth, and light, only knowledge and enthusiasm are needed for productive agriculture to start (cf. Holdridge, 1959).

Water and fertilisers are essential catalysts of photosynthesis; they control the area of leaf that will be exposed to sunlight. This is generally recognised so that irrigation and fertiliser production have a prominent place in the policies of the international organisations. Skilled attention is needed to maintain an optimal environment for photosynthesis. This means that drainage as well as irrigation should be attended to, and research on actual fertiliser needs should replace the casual or traditional applications

that are wastefully common now. But, having established the environment, it is important to make sure that we are growing the right plants.

Plants, if suitably chosen, can supply all the essential components of a diet. Their use as sources of starch, fat, vitamins, and flavouring agents is so well known that insufficient stress is put on them as protein sources. The cereal grains are generally referred to as "starchy" foods although they contain about 10%* of protein—that is, two-thirds of the amount needed in an adequate diet. An increase in grain production is vital, for it is better to have a low-protein diet than be hungry, but it is not sufficient. Every increase in the supply of foods containing less than 15% of protein increases the need for a supply of foods rich in protein if that balance is to be maintained; this is especially difficult in those tropical areas where cassava and yams play an important part, for these roots contain very little protein.

Peas, beans, and many leaves and immature flowers contain 20–40% protein. The last have the serious disadvantage of being perishable so that they are of little use as a food reserve in countries where there are seasons in which growth stops as a result of cold or drought. But one of the more important differences between a modern European or North American diet and a medieval or tropical diet is the prominence of green vegetables in the former. Alongside the commendable effort that is now being put into selecting and cultivating improved varieties of tubers, and cereal or legume seeds, more could usefully be put into vegetable cultivation. The productive kitchen-garden of temperate regions is only a few hundred years old, but in that time an immense range of useful vegetables has been developed. These generally do not grow well in the tropics and there has been a tendency to dismiss local production as impracticable and satisfy what taste for vegetables there is by importing deep-frozen produce. As a result, vegetables are expensive and little used. In many tropical areas, pot-herbs are collected from the bush and used on a small scale; for example, various amaranths are used in West Africa. These plants would be a useful starting-point from which plant-breeders should be able quickly to develop productive domesticated varieties. Work that took the old plant-breeders centuries could probably be done in a few years by modern methods.

* Percentage of the dry matter.

NEW PATTERNS NEEDED

An increased consumption of vegetables will improve the world's predominantly inadequate diets but will go only a short way towards solving the problem. More of the basic foodstuffs can obviously be got by the use of more land and better husbandry. When unused land is not available, this means the diversion of land from one use to another; particularly it means growing food on land that is now not growing food, or not growing food consumed locally. The advantages of this depend on economic arguments. Is it better that a hungry tropical country should export cotton, rubber, sugar, and jute so as to get money with which to buy wheat, meat, and dried fish; or should it grow cereals, beans, and vegetables on its land and eat them? The answer generally given is, "the former", but the answer, though plausible, is not altogether convincing, for two reasons. The under-fed regions with which we are primarily concerned were first developed as colonial territories by people with an interest in cash crops and with little interest in the state of nutrition of the indigenous population. The population, and the problems, have developed since the pattern of agriculture was laid down, but conservatism is one of the more powerful influences in agriculture. Whatever its merits at one time, the original

FIG. 1. One way to increase yields is to breed for resistance to pests and diseases. There is also the possibility of improving frost-hardy varieties of plants which will permit greater use of the spring sunshine.
(By courtesy of United Nations)

FIG. 2. Improper drainage from near-by irrigation canals has resulted in a waterlogged surface which is useless for agriculture. If the optimal environment for photosynthesis is to be maintained, drainage as well as irrigation must be attended to, and the actual fertiliser needs of the soil should be studied.

(By courtesy of United Nations)

pattern of agriculture may now be unsuitable. Again, when comparisons are made between yields, either by weight or financial return, given by cash crops and food crops, it is important to remember that the former are generally produced by efficient mechanised methods making use of the best modern knowledge, whereas the latter depend on peasant farming by traditional methods. Naturally enough, the cash crop often appears preferable. In many parts of the world it would probably be advantageous to replace some of the large-scale intensive production of crops that are not eaten locally by equally large-scale and intensive production of those that are. And when this is done, care should be taken that what is grown is a rich source of protein and vitamins rather than of starch and fats, for the latter satisfy hunger but do not supply the materials most often needed.

The problem of finding out what ought to be done in each area is difficult, but it is not as difficult as finding out how to put it into practice. Many experienced observers maintain that the immediate food problem would be solved if the farming standards of the incompetent many could be brought up to those of the efficient few. Exhortation alone will not achieve this, nor, apparently, will hunger. Some people advocate large farms, and it is indisputable that some of the most successful tropical developments have been run by dictatorial private enterprise. But this technique is not likely to last. People like to be consulted; when they have been, they may consent to sweeping changes in their way of life. FAO makes the wise proposal that "Community development and education in living constitute a new and promising approach to the problem of rural poverty which was never tried on any extensive scale in the earlier industrialised countries. It seems to offer a means of overcoming at least the worst disabilities of rural poverty at a more rapid rate than would be possible under the free-enterprise type of economic development of the past." The only comment that need be added is that, although under-developed areas may need advice, they are in still greater need of the means to follow the advice.

Consent is a matter both of fact and propaganda; neither can succeed without the other. The old adage, "Good wine needs no bush", is only true in a community small enough and talkative enough to pass news round without organisation. Projects that have failed have generally done so for many reasons, and one cannot pick out one and say, "This was the cause of the failure"; the project would not have failed had all else been perfect. Thus there would have been no riots and sluice-wrecking in the 17th century, when the fens in East Anglia were drained, if the work had been done for the benefit of the fenmen rather than of the landowners, or if the landowners had had a publicity service adequate to convince the fenmen that, while the motive was the benefit of the landowners, the project would in fact benefit the fenmen too. We now see that drainage was a

good thing, but most of us would have been among the dissidents had we lived in East Anglia at that time. Similarly, the scientific inadequacy forced on the Ground Nuts Scheme by political expediency could have been overcome and the project got on to a sound footing if influential opinion in Britain and Africa had ever been rallied in full support. One section of British criticism would have been silenced had it been apparent that the project was intended to benefit the Africans rather than us, and this would not have aroused any more hostility from the other set of critics.

More than 30 million tons of fish are landed every year and fish is a main foodstuff in several countries, but, averaged over the whole world, the daily supply to each person from this source is about one gram of protein. Some of the world's potential fishing-grounds, the South-East Pacific and Indian Ocean, for example, are under-exploited, and the figures published by FAO show that, even in well-fished areas, landings can be increased. International tension over fishing in coastal waters shows, however, that there is anxiety lest increased fishing should interfere with spawning. Fishing is the only aspect of food-getting that has undergone no fundamental change during the last 50,000 years; it is still just hunting for a wild animal. We try to protect the young, as hunters do with many other animals, and we have improved the hunting equipment, but, in the sea, little or nothing has been done to increase productivity. Fresh-water fish-ponds are much better organised, and there is a welcome enthusiasm for them in many countries, but their potentialities are, of necessity, much smaller than those of the sea.

The sea, like the land, is productive because of photo-synthesis, and this is limited by the supply of nutrients—notably nitrogen and phosphorus. At first sight, therefore, it would appear possible to fertilise the sea as we do the land. But fertiliser, unless applied foolishly, stays to a great extent in the useful top layer of a field whereas in the sea it spreads into the useless dark depths. Nevertheless, we can be sure that the element of hunting will diminish as time goes on and that there will be an increase in marine husbandry, with deliberate encouragement of desirable fish and discouragement of useless ones. The process will be sustained by a brisker photosynthetic cycle catalysed by the introduction of nitrogen and phosphorus into suitable areas. In principle, greater productivity could be attained by more thorough mixing, for bottom water contains very much more phosphorus than surface water. If a power station is ever made that uses the temperature difference between deep and surface water in the tropics as its source of energy, and if it brings the fertile bottom water to the surface, fish should be a valuable by-product of its working. Similarly, nuclear energy could be used to heat the bottom water and bring it to the surface. Unfortunately, fertilisers are not the only thing we are putting, or are likely to put, into the sea.

Sir John Lauder, 250 years ago, spoke of the River Tweed, "which demits in the sea which is the latrons and receptacle of the universe". This tradition has been maintained. Domestic sewage is inaesthetic; it may be a health hazard, but it is a fertiliser. Industrial wastes, especially those that are radioactive, are a new and increasing menace. Recognition of this is growing, but the main effect so far has been to make the authorities in Britain and U.S.A. more furtive in using rivers and the sea as dumps for nuclear wastes. The vigilance of coastal communities, especially in New England, is forcing the dumpers farther out to sea, but not even the abysses offer a permanent answer. Various marine animals were seen below 6000 fathoms in the Pacific; this means that oxygenated water gets down, and therefore that abyssal water gets up to the surface. The scale of the present problem was fully described at the Monaco conference on nuclear wastes; the world is already producing 11 million gallons of radioactive waste a year and the "atomic age" has hardly begun. When it gets into its stride, if present methods of waste-disposal continue, a serious rise in marine radioactivity is feared. Responsible oceanographers therefore condemn marine dumping. The alternatives are ejection of the wastes into space, which seems a most useful job to which we can put cosmic rockets, or storage on land. Each will be vastly expensive. Referring to the second alternative, a WHO bulletin remarked, "The tombs of radioactive waste are becoming as elaborate and expensive as those for the mummies of the Pharaohs." These considerations are highly relevant to the problem of world food supplies. If the present irresponsible attitude continues, fish and other marine products may become potentially lethal components of a diet.

THE AVOIDANCE OF WASTE

Waste and inefficiency are matters of degree and opinion. They are often very convenient and they are sometimes associated with such great improvements in the quality of a food that they can be tolerated so long as their consequences have been thought out logically and quantitatively. Thus, water-borne sewage, and the use of animals to convert plant protein into the more highly esteemed animal products, lead together to the loss, in round figures, of 10 million tons of fixed nitrogen a year. This is a third of the amount that comes down annually on land in rain; it is also the amount that is fixed by the chemical industry. The loss is therefore serious, but it may be indulged because it is well recognised. The aesthetic and gustatory advantages can be weighed against the cost and, if the balance is at any time found unsatisfactory, our practices can be changed. Unrecognised wastes are more serious.

Pests and diseases are beginning to get adequate attention. They rob the world of at least £20 thousand million worth of produce—a figure that looks impressive even alongside military expenditure. It is so obvious that time, effort, and land are wasted when a crop is cultivated but no harvest is gathered that most governments and the international organisations are attending to the problem, though hardly on an adequate scale. The circumvention of this loss, together with the extended use of fertilisers, could satisfy our immediate needs for food.

The misuse of products that have already been harvested is less widely recognised. For the most part, these are by-products and the producers' attention is so firmly focused on the primary product that they tend to be neglected.

The residue left after extracting oil from various crops is an obvious example. There are no completely reliable figures for the amount since much of it never comes into the channels of world trade; furthermore, it varies in value from soya meal containing 45% protein to coconut meal with 20%. The world total of crops for oil production cannot be less than 70 million tons a year, however, and that means 20 million tons of protein, since more than half the total comes from high-protein seeds—soya, groundnut, and cotton-seed. That quantity would give everybody in the world about one-third of their protein requirements. At the present time only a tiny fraction of it goes directly into human nutrition; the rest, at best, feeds animals, but in many parts of the world it is used as fertiliser or is even wasted altogether.

Traditional methods of handling oil sources depend on the assumption that the oil is the important thing and the protein a by-product. Anyone impious enough to suggest that this is not invariably so will be told by "practical" men (who, as T. H. Huxley phrased it, "practice the errors of their forefathers") that they do not understand the economics of the industry. This is probably true, but the world is more in need of protein than of oil. Attention should therefore be given to the possibilities of extracting oil by methods that do less damage to the protein and leave it in a more palatable state, even if these methods should be rather more expensive or leave a little more of the oil unextracted. If both products are destined to be human food, it matters little whether the oil is consumed as oil or as a residual component of groundnut, cotton-seed, or coconut meal. There will undoubtedly be difficulties in making any changes in the techniques now used, but the amount of protein at issue is so large that it would be worth while solving them. It is encouraging that some steps in this direction are already being taken, notably in Central America and India.

NEW SOURCES AND TECHNIQUES

Potential sources of food are wasted in two ways. Some are discarded as rubbish, others are inadequately or inefficiently used. Leaves come into both categories. When they are by-products from crops such as sugar-cane, jute, potatoes, sugar-beet, and some peas and beans, they are generally burnt or ploughed in; they are also grown specially as forage for animals. Most leaves cannot be eaten directly by people and other single-stomached animals because they contain too much fibre and may be poisonous or unpleasantly flavoured. The problem is to separate the valuable components from the fibrous and strongly flavoured components, and there is machinery for doing this satisfactorily.

Protein made in this way can be eaten in many different forms, for it has little or no flavour of its own. Experiments on pigs, chickens, and rats show that its value is similar to fish meal, and this is what would be expected from its amino acid composition. This then is another aspect of the avoidance of waste that would repay intensive study. Instead of wasting leaves, or feeding ruminants on high-quality forages and getting back about a tenth of the protein the animal consumed, we should process the leaves mechanically and get half to two-thirds of the protein as a direct human food. Animals could still have the residues. There is no reason to fear that the pleasure of eating animal products would disappear under a vigorous policy of leaf protein production. Furthermore, there are vast areas of range land that are probably better adapted to grazing animals than to any form of arable farming. The most tangible result of a change of policy would be that people who now get little plant and less animal protein would get a better diet. Nevertheless, the production of leaf protein should not be thought of as a general solution to the world's protein shortage; it is simply quoted as an example of an up-to-date approach to the problem. The guiding principle is that it is generally more economical to separate an intractable mixture into its useful components than to pass the whole mixture through an animal converter. Tacitly, we accept this proposition when we thresh and winnow grain.

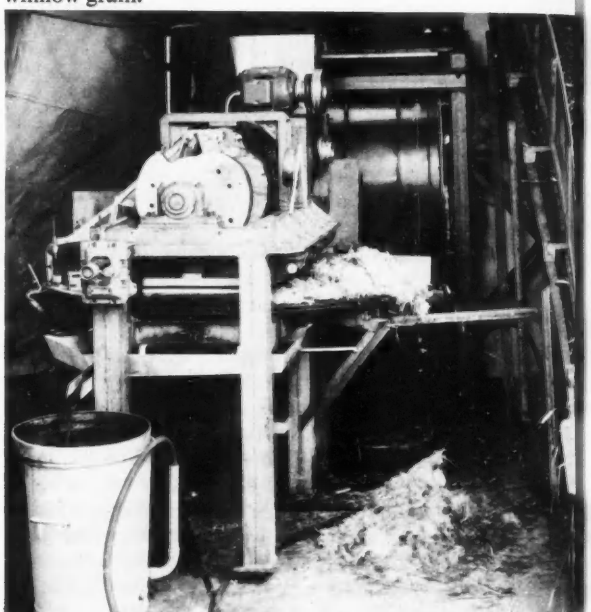


FIG. 3. Protein-containing liquid being pressed out of wheat pours into container at lower left as spent fibre is ejected from opposite side of press.

Once the practicability of leaf protein production and use have been generally accepted, the problem of selecting ideal plants from which to make it will arise. So far, normal agricultural crops, bred and selected for other purposes, have mainly been used. Vigorous weeds and other wild plants should be tried and then plant-breeders should be encouraged to develop more productive strains from them. With a quarter of a million plants to choose from, the criterion should be: find what will grow well in an area and then devise a use for that. Much could be done on dual-purpose plants. The leaves of sugar-beet and many peas and beans are useful protein sources, and the leaves of some fibre plants, such as jute and ramie, would probably be useful too. Ideally, what is wanted is a plant with leaves from which protein can be extracted, a stem con-

taining good fibre, edible tubers, and a useful seed. It will be difficult to get all that at once, but it is good to have high ideals.

During the past fifteen years algae have been widely and enthusiastically advocated as sources of food. This advocacy springs partly from an attempt to meet the restrictions of a special environment, partly from a search for novelty, and partly from illusion. The first two may be treated sympathetically. Algae, like other plants that live submerged, do not have a transpiration stream and are therefore more economical with water than normal land plants. Where there is an acute water-shortage—in a desert, for example—it might be easier to put a transparent water-conserving roof over an algal pond rather than over a field. But where water is abundant there is no reason to think that algae offer any advantages. Brief, laboratory-scale experiments have given *rates* of photosynthesis equivalent to fifty tons dry matter per acre per year; during the best weeks of the year good farming can produce at a comparable rate. Illusion comes in when the colder weeks of the year are forgotten. It seems certain that, even in absolutely flat country, the installations needed to grow algae would be considerably more expensive than a ploughed field.

Synthetic food is a constant theme, dream, or nightmare, of science fiction. If the word synthetic is not defined too rigidly, there is no difficulty about it in theory; it is just a matter of economics. Plants make starch and cellulose so efficiently and economically that there seems little prospect of competition from synthesis starting with limestone or coal. There is even less prospect of protein synthesis in the factory, but it may well be made by micro-organisms, starting from sugars and inorganic nutrients. The possible rates are impressive. In twenty-four hours, half a ton of bullock will make a pound of protein, but half a ton of yeast will make fifty tons, and only needs a few square yards to do it on. When, in the future, we are concerned with shuffling the organic materials that plants have already made, it is certain that micro-organisms, rather than animals, will be increasingly used. As an intermediate stage greater use might be made of the micro-organisms already inside a ruminant. The rumen flora of a cow can make protein out of urea, and this is then used by the cow. Urea is a cheap synthetic product and can replace much of the protein in a cow's food.

Already many vitamins and amino acids are being made synthetically and added to food and fodder. This type of synthesis is bound to increase. But if we were wholly logical, more attention would be given to much simpler synthetic products such as acetic, succinic, and malic acids, alcohol and glycine. These are all present in varying amounts in conventional foods, they are good energy sources, and are much more reasonable subjects for bulk synthesis than sugars and fats.

PALATABILITY AND ACCEPTABILITY

Most people approach novelties suspiciously and sceptically—a very reasonable attitude in view of the antics of some commercial organisations. Whatever changes are made in food, the bulk consumed in a day by an adequately fed person will remain much the same. The idea that eating will degenerate into swallowing a few pills is nonsense; 3000 calories will not pack into less than three-quarters of a pound dry, and by the time it is presented in palatable form it will weigh about two pounds, as it does now. Some people also argue in favour of a complete diet packed as a powder. Why? People like variety and there are no conceivable normal circumstances in which all of even one component of a diet would come from one source. Although emphasis may in time move to new sources of food, the basic forms of cooking and presentation are likely to remain much as now. Recognising this, and recognising that changes are needed in some parts of the world now and will probably be needed in more parts of it soon, skilled imaginative work is needed on the presentation of novelties, such as fish flour, oil press-cake, leaf protein, and yeast or other micro-organisms. This is work that should be done now, quietly and persistently, and not postponed until the need is even more acute than it is at present.

One reason why these things are not done is that there is little demand for the new products in the places of need. People are as conservative at table as they are on the farm. This, and ignorance, rather than physical obstacles to the production of more food, is the source of much of the world's present malnutrition. But people cannot begin to yearn for foods they have rarely seen and hardly tasted. The first step, therefore, is for governments in the malnourished countries to recognise what has happened in the rest of the world—the porridges are disappearing and the stews or gallimaufries are being sophisticated into goulash. "The good old days", for whose return some sigh, led to exigency interspersed by occasional orgies; there is more well-being with the "international cuisine". The transformation demands propaganda; its effectiveness is shown by the phenomenal sales of expensive patent foods. Their merits are clearly disputable, but the less the merit the more interesting is the success of the advertising campaign. If the same skill and enterprise were devoted to a better cause a nutritional revolution could be brought about.

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MORE FROM THE LAND

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There are now less than four acres of cultivable land per person, and half this amount is already in use. Exploiting the available land would only provide a temporary solution to the food problem. The answer must be sought in a variety of ways.

FIG. 1. This traditional Moroccan harness hurts the animal and does not make the best use of the draught power. Production could undoubtedly be increased if better implements could be provided where needed, but it is a mistake to think that only elaborate and expensive apparatus is necessary.

By far the greater part of the earth's surface is covered by seas. Of that covered by land, the greater part is made up of frozen waste, desert, mountains, and rock, which for the most part cannot conceivably be made to grow food. The land which remains, cultivable in varying degree, amounts to something under four acres a head. About one half of this is at present cultivated; on the rest, cultivation might in some instances be fairly easy, but in other instances would involve considerable cost and effort in clearing, draining, irrigating, controlling of pests, or elimination of human disease.

We have then to ask three questions. To what extent would food be adequate for mankind when produced in the best conditions from the maximum area of rather less than four acres a head? What is being done to get all the possible area of land under cultivation? What is needed to make the land produce the most food?

To none of these questions can we give certain and unequivocal answers. Least of all is there a simple, single answer concerning the area needed to produce food for one person. Vegetable foods are produced from simple substances in the air and in the soil, by the action of the sun upon green leaves. Animal foods—like meat, eggs, and milk—are produced indirectly, by conversion from vegetable foods. In the process, the maintenance of the animal accounts for the major part of its own food; only a small part is left over for conversion into what will ultimately be man's food from the animal. So it comes about that, given similar and good conditions of soil and climate, a man could manage to feed himself with perhaps as little as half an acre if he were eating almost entirely vegetable foods, but would need more like two acres if he were eating a fair proportion of animal foods. We must accept that there are great differences in natural and dietary habits which are not easy to change. It would then be quite realistic to say that we need only calculate on the basis of about one half acre, and that we could get all we needed from a restricted diet. In realistic terms, we must allow for something over one and a half acres a head of reasonably good land, well cultivated and well watered, if we are to produce enough food.

We have seen that there is as much again which could be cultivated. Yearly, more and more is being brought into use. But there are no longer the vast, undeveloped tracts of land, such as those which came into use in the last three or four hundred years, first in the New World and more recently in Australia and New Zealand. At the same time, land is being constantly lost by erosion.

Over the centuries, many large deserts have been created by man. North Africa was at one time the granary of the Roman Empire. Palestine really did flow with milk and honey. In more recent times we have created the dust bowl of the Middle West of the United States. Only recently have we begun to learn, or relearn, that soil erosion can be prevented. Some of the methods are fairly simple, such as the building of terraces or, even more simply, contour planting. The importance of trees and shrubs is also more clearly recognised today, as can be seen in the great afforestation projects in even such tiny countries as Israel. By these means, the loss of land is being slowed down, at least in some parts of the world. In other parts, by removal of rocks, by irrigation, and by the judicious use of fertilisers, desert is also being reclaimed.

Cultivated land areas can also be extended by the

development of new varieties and breeds. Sometimes this is a matter of getting varieties which can come to harvest in a shorter time, and so are suitable for areas which, because of latitude, have only a short growing-season. Sometimes it is a matter of getting breeds of cattle which are resistant to diseases endemic in particular areas. As well as by breeding, this may be done by developing pesticides which can control the diseases. We may mention one further factor, and that is the use of the land for the cultivation of non-food crops. Man-made fibres and synthetic rubber are two example of materials which can possibly release land for food production.

INCREASING THE YIELD

In all these ways, then, we can both increase cultivable land, and reduce loss of land already under cultivation. We must now consider methods used for ensuring maximal yields of food from the land. Within the last two centuries, great increases in production have come about from the application of scientific principles. Breeds and varieties have been developed which give much better yields, and are resistant to attack by pests and parasites. Methods have been developed for attacking such infestations and diseases as well as for eliminating the weeds which compete with crops. Fertilisers have been made available from a variety of unexpected sources, including the nitrogen of the air; we are able also to determine much more accurately which fertilisers are likely to be needed, and the most economical ways of using them. Mechanisation has led to spectacular increases in production. In some instances, for example in arid lands requiring irrigation, great advances have come from the availability of cheap power. With the newer methods of harnessing the winds, and with the promise of energy from the sun and from the atom, much more can be expected. Perhaps the simplest effective summary of the situation is that, even in a country like Britain with a highly organised and advanced system of agriculture, the most efficient agricultural practice results in twice as much production as the least efficient. In other countries, lacking fertilisers, weed-killers, modern equipment, and access to good seeds and breeds, there is even greater room for improvement.

It is a mistake to think that only elaborate and expensive machinery, tools, or chemicals are necessary to increase the yield of the land. In Ethiopia, the recent introduction of the scythe makes it possible for one peasant to produce significantly more from the same fields. In Israel, methods have been rediscovered for the collection of substantial amounts of water in the form of dew, in areas of very low rainfall. Again in Israel, it appears that fairly simple wind machines can be used to produce energy for irrigation. Sometimes, it is true, a fair amount of capital is needed initially, but the result is a substantial improvement in yield, at lower cost. This is the case with the production of so-called "broiler chickens", and similar developments are taking place in regard to the production of veal and pork.

The limit to yields of food is somewhat a deficiency of man-power. As we have said, there are no longer huge areas of land waiting to be opened up as there were in North America. Nevertheless, there are smaller areas which could be made productive if people could be induced to live and work on them. As a Zionist pioneer once said of the Negev in Israel, "This land is not a desert; it is simply deserted." Again, we saw that yields of food are very frequently lower than they might be. Clearing and preparing the soil, bringing in water, protecting the crops, taking the harvest—in many parts of the world the provision of more man-power could mean the production of more food.

That one needs man to produce food for man is often forgotten in discussion on food and population. Consider, for example, the measures taken to control and treat malaria. The result certainly is that fewer people die of the disease, and there are consequently more mouths to feed. But there are also more pairs of hands to produce food. Less obviously, the elimination of disease from those whose energy is constantly sapped by fever makes it easier for them to produce food, and not merely consume it.

EDIBLE FISH

We have so far considered food only from the land, yet some of our food comes from fresh water and sea water. While some people, living on the shores of rivers, lakes, and sea, consume large amounts of fish, the average world consumption is less than 2% of the diet. It is said to be less than one-ten-thousandth of the amounts which are constantly being produced in the sea. One reason for this low figure is that, until recently, it was difficult, if not impossible, to transport fresh fish for more than short distances, and dried or salted fish is not always appetising. With developments in methods of preservation, people living far inland—at least in the advanced countries—can now have chilled, frozen, canned, or dehydrated fish at almost any time. The other reason why fish is, for most of us, only a small part of our diet is that we have not yet learned to cultivate the waters in the way we have cultivated the land. Just as we used to hunt for wild animals and gather wild fruits, berries, and roots, so we still hunt and gather the produce of the seas, rivers, and lakes. Only

FIG. 2. Many large deserts have been created by man over the centuries. Dune fixation and reafforestation are now among the most important tasks of plant-protection experts.

FIG. 3. The greatest nutritional problem in many under-developed countries is lack of protein. A solution developed by Indonesian farmers is to grow fish in flooded rice-fields. Each acre then produces not only rice but double the weight of its rice-yield in edible fish.
(All photographs by courtesy of the United Nations)

in the most recent times have we even begun to develop better methods of locating this produce. The use of sonic and radio methods for this purpose is not much more than ten years old. Even newer are the studies of ocean currents and tides which are leading us to better knowledge of the habits, developments, and paths of migration of edible fish.

There is, however, an interesting exception to the generalisation that we do not cultivate the waters in the way we cultivate the land. In a few countries, notably Indonesia and Israel, fresh-water fish are deliberately bred and grown, and give useful yields of food. In Indonesia, and also more recently in parts of Japan and China, the fish are cultivated in the rice paddies, which are thus made to produce simultaneously a double crop.

The food available to man is significantly less than the food which has been grown and harvested. Much is lost by insects and rodents, or by moulds and bacteria, or by chemical deterioration. We do not know exactly how much this loss is, but it is probably something of the order of 10%—enough to feed more than 300 million people. Methods of safe storage are fairly well worked out in the advanced countries, but these are often expensive and elaborate. There are many new methods being tried out, which are likely to be more readily applicable in under-developed countries. They include the use of treated paper bags, mud silos, and plastic containers for storage, and inexpensive chemicals for elimination of pests.

One factor affecting our food supplies, which we have mentioned in passing, deserves consideration for a moment longer. This is the processing of food. Man has for centuries dried food in the sun, or salted it, or made another and less perishable food from it—for example, cheese from milk. But since the invention of canning, 150 years ago, the food manufacturer has developed many new ways of preserving food, and improved many old ways: freezing, drying, smoking, and, perhaps soon, irradiation. The effect of this is twofold. In a direct way, it allows food to be kept and then eaten which would otherwise have to be discarded. In an indirect way, the farmer, or the fisherman, need not now confine his production, or restrict his catch, to considerations of immediate consumption. He will often find the food manufacturer ready to encourage his production and to assure him of a good market for his produce. Thus, in Britain, far more peas are nowadays produced than could possibly be eaten fresh during the very short season of less than two months. But they are produced deliberately for processing in cans and frozen packs, and so are being consumed throughout the year.

DISTRIBUTION

We have not so far discussed one of the most important problems of food supply—the problem of distribution. What we have said so far implies that, if we produced enough food anywhere in the world, we should somehow automatically have ensured adequate food for every individual. The facts, of course, are quite different. To have the food it needs, each country must either produce it or must be able to pay for foods to be imported. The United States and Australia are examples of countries which produce all the food they need—and more. Britain is an example of a country which produces about half the food it needs, and can afford to buy the other half. But the majority of the world's population lives in countries which do not produce enough and which cannot afford to buy the rest. The more advanced countries, too, with their adequate food supplies, are also those which have the resources further to increase their food production. They can afford to mechanise their farms, to use fertilisers and weed-killers and pesticides, to plan long-term experiments on breeds and varieties, to irrigate, fence, spray, and build. All of these things are very much more difficult for countries which are less well off, and where food production is already inadequate for proper health and well being.

And so it comes about that in advanced countries there is deliberate restriction of food production. We now rarely see, as we did before the war, the burning of harvested corn. But while "poverty in the midst of plenty"—the shameful slogan of the thirties—is perhaps not so true today, it can well be argued that there is poverty in the midst of *potential* plenty. And in spite of restrictions, the rate of increase of food production in the advanced countries is significantly greater than the rate of increase in the under-developed countries. In the former, food production is increasing faster than the population. In the under-developed countries it is the population which is increasing faster than food production. It is difficult to avoid the conclusion that the reason there are so many hungry mouths today is not because we do not know the ways to produce enough food but because we are so stupid, or perhaps so selfish, that we cannot solve the economic problem of distributing the food.

THE TWO ASPECTS OF SCIENCE*

Sir GEORGE THOMSON, F.R.S.

Determinism and long-range predictions, the interaction of sub-atomic particles, the partial atomicity seen in biology and astronomy—these are only a few of the partially charted regions on the large continent of ignorance. A fuller understanding will require a creativity that ranks with the best found in sculpture, music, and literature.

Sir George Paget Thomson, President of the British Association for the Advancement of Science, Master of Corpus Christi College, Cambridge, Nobel Laureate (1937) for research on behaviour of electrons.
(Reproduced by permission of the Saturday Evening Post *and Eugene Kammerman)*

Science is already valued for what it can do to increase man's control over nature, and feared for what some of its consequences may be. Some would have us consider these consequences as the sole justification of science. This view, or something very like it, is the official attitude in Marxist countries, and there are many in this country and in U.S.A. who would be horrified to be told they were Marxists but who without any explicit statement do in fact act and speak as if they thought the same. But this view is too limited. There is a second aspect and it is this.

Science aims at understanding the nature of things; in this it is at one with religion and philosophy. But its approach is the opposite. These last try to gain knowledge of the whole, in the one case by an awareness of the deity, intuitive or revealed, in the other by building with words a system of thought which can account for fundamentals. Science starts from the other end. It begins by studying details, often apparently trivial details but things which are queer and appeal to human curiosity. Things like black rocks which attract iron or rubbed amber which makes chaff fly.

This has been more successful than one could have expected. It is a method difficult to defend *a priori*—it has often been made fun of. Swift ridiculed the philosophers of Laputa who studied how to make sunshine from cucumbers, but the method works.

From the study of details such as these come *concepts*, these concepts, or some of them, show vitality and take charge, as characters in fiction are said by authors to do.

They are the bases for hypotheses and "laws", they are the things that get names —mass, energy, temperature, entropy, wavelength, charge, electrons, quantum numbers, to take some examples from my own subject.

Some do not survive: caloric, phlogiston. Others are deposed from their independence and become vassals of the more successful, as mass has of energy or valency of electronic structure.

CONCEPTS UNIFY THOUGHTS

But the successful concepts—or the best of them—are not concerned with details any more, they penetrate deep into the heart of things. Electrons, for example, are regarded as present in all ordinary matter, and in any attempt to explain the behaviour of matter, physical, chemical, or ultimately biological, one is, if one goes deep enough, forced back on to them. At present they stand as a fundamental concept, but even if, as is quite possible, they ultimately come under some still more general idea, the concept of an electron will still be used, as mass is in mechanics. It unifies our thoughts over a vast area of facts.

Thus there is excellent reason to believe that the whole of chemistry is explicable in terms of electrons and the wave functions which describe their location. This is an enormous simplification of thought, even if the maths are too difficult to work out in most cases. It does not much matter from this point of view that test tubes are cheaper than electronic computers if you really want to know the answer to a practical question.

Scientific concepts enable certain aspects of the enormous complexity of the world to be handled by men's minds. They are suggested mostly by experiment but partly by mathematics, and controlled by the need that they should not lead to illogical consequences.

These concepts represent an extension of the human intelligence. They are not easy; many have subtleties which, for example, oblige the populariser to take anxious care lest in trying to simplify he make statements which are simply untrue. Some are more fundamental than others, but even those which turn out to be only rough pictures of what really happens often retain their usefulness. They are sketches as compared with finished pictures, and if details are not needed the sketch is often clearer.

Concepts are discoveries as well as, indeed more than, inventions. They have more in common with the discovery of

* Presidential Address delivered to the British Association at Cardiff on August 31, 1960.

America than with the invention of the spinning jenny or of the electronic computer. Some at least have been forced on unwilling minds by hard facts and have resisted many attempts to displace them. I am thinking more especially of the quantum theory.

Not merely are they an exercise of the human mind which equals the brilliance of any system of thought, philosophical or even mathematical, but they represent reality.

The nature of the relationship is to me a mystery, but they are certainly not merely the product of the human mind.

Science is a pyramid based on many varied facts, topped with a crown of ideas reaching to the skies. These are its fruit but can change without affecting its stability. I sometimes think that in philosophy the pyramid is the other way up!

KNOWLEDGE FOR ITS OWN SAKE

What we want as scientists—I am sure in this I speak for the great majority—is that the world should realise that we are not interested merely in making possible new drugs, television sets, or weapons, though all these are important, but in enlarging the bounds of human knowledge.

The greatness of the human race is indeed many-sided. Thus in the world of art there is a difference between the ability to compose or interpret a great piece of music and that which writes a great novel or paints a great picture. Yet all are evidence of greatness and worthy of the name. Still more so is moral greatness. "There is one glory of the sun and another glory of the moon and another glory of the stars."

I have no desire to exalt our profession unduly, but surely the ability to understand, even to a limited extent, the world around him is one of the powers of which man has good right to be proud. Indeed it seems to be the one which most divides him from the animals. The lark's song, the heroism of a plover luring an enemy away from her young, the cat who was seen to attack a grizzly in defence of her kittens—these, if taken at their face value, are notable even by human standards, but I am not aware (though I speak with great diffidence) of any creature which even appears to be trying to discover any general principles.

The chance of understanding things of fundamental and permanent importance is what makes the pursuit of science fascinating and worth while.

These two aspects of science do not in fact conflict. The best way to make advances in technology, whether on the medical or the engineering side, turns out to be to understand the principles. This is quite a recent discovery, indeed it has probably only recently become true. It would not have been much use for example to man in the Stone Age, or even a few hundred years ago, to try to understand the principles of tanning with no basic knowledge of chemistry to guide him. He did better by trial and error. Even the steam engine was developed with little knowledge of the determining principles, though the best scientific minds of the day were much interested and the thought they gave it advanced science by discovering thermodynamics.

Electrical engineering was the first important activity to be developed from the start on scientific principles, and even here Edison did great things on a decidedly sketchy knowledge. But increasingly more discoveries are made in research laboratories and fewer by workmen on the bench. This is what one might expect. As fundamental principles get known it is possible to use their consequences intelligently. Often these consequences are too complicated to be calculated, but knowledge of the principles is an enormous help by showing in a general way what is likely to happen.

Then of course there are the modern technologies which derive directly from some important new basic discovery, such as electronics and nuclear energy.

This dependence of technology on pure science is now pretty generally recognised by industry. The more progressive industries maintain research laboratories which both make use of the basic discoveries made in the universities and elsewhere, and contribute their own. These laboratories may be owned and operated by individual firms, or be co-operative efforts of an industry in the form of Research Associations substantially helped by Government. There are black spots, of course—industries which spend too little on research or organise it badly—but broadly speaking the need is realised and reasonably well met.

POINT AND COUNTER-POINT

Pure science receives a great return for what is contributes to technology, and this in two ways, materially and in the realm of ideas. Consider first the material return; a modern physics laboratory could not work without instruments developed for technology and obtainable cheaply because industry needs them in large numbers. Take just two examples out of many. The use of high vacua—and how important this is—has been enormously facilitated by the needs first of the electric-light industry and then of the manufacturers of radio valves. Again, the complicated electronic devices which crowd every physics research laboratory would be impossible without the cheap components of all kinds manufactured originally for radio and now for television. For this return by industry I sometimes think we academic scientists are not as grateful as we ought to be.

The other influence of technology is more subtle but as important. As science advances, concepts tend to become more and more abstract, farther from anything than can literally be touched or handled. To take a simple case, energy is more abstract than mass which it replaces. In the higher flights of theoretical physics abstraction goes much farther. Is there not a danger that one may lose touch with reality, and end up by supposing that some elaborate piece of mathematics represents reality when it is only a creation of the mind, inspired indeed by physical reality but no more like it than is a modern picture? I think we are safe as long as the people who make these theories are reasonably close to them who use them, not merely in laboratories, but in industry.

A theory which involves detailed consideration of the behaviour of particles less than a millionth of a millionth of an inch across would have seemed to Swift too absurd to be even worth ridicule. Yet one cannot regard it as a pipe-dream when it leads to the great reactors of Calder Hall or Chapelcross. To me, the most amazing thing about science, and the most surprising and exciting fact about our world, is this astonishing connexion between highly abstruse theoretical ideas and the matter of fact, in this case the housewife boiling her kettle with power from nuclei. This surely adds an immense thrill to discovery. I have no sympathy with those who regard technology as intellectually a poor relation of science. To me, science without technology is incomplete and inconclusive. Systems of philosophy come and go; some are perhaps true, but who can tell? But when conclusions deduced from precise experiments by mathematical theory lead to detailed predictions from which working machines can be designed, machines which without the theory no one would have thought of in a million years, then indeed one knows that one lives in a universe which is rational and that one has found the key to one of its rooms.

THE INFLUENCE OF SCIENCE ON THOUGHT

May I remind you of a few of the ways in which scientific knowledge has influenced and is influencing thought and

the intellectual climate of the world? First and most obvious is the idea of evolution, that things change consistently and pass through successive stages, whether they are mice or stars. That living creatures in particular not only go through individual changes, but that in the flow of generations changes come over the race, or over a part of it, and that these changes lead to profound differences like those which distinguish men from molluscs. In the year of the centenary of the "Origin of Species", just past, you have heard the profound consequences of this idea described much better than I can.

In the course of my life the quantum theory has produced a revolution in physics comparable with that produced in biology by Darwin. We have been forced, some of us very unwillingly, to believe that at bottom the laws of physics are not statements of what *must* happen, but of the relative chances of a variety of alternatives. That the determinism of the planets, for example, occurs merely because planets are enormous on the atomic scale and their distance from the sun very large, and that the *Nautical Almanack* would be impossible if the solar system was reduced to the scale of a molecule. Certainty comes with a massive body, or if the bodies are small one must have very many of them so that the laws of statistics can manufacture near certainty out of highly uncertain events, as they do in life insurance.

This makes quite a difference to the way one regards the world and I think its consequences are still not realised by the average educated man, though it has been accepted by the majority of physicists for thirty years. It shows for one thing how dangerous it is to extrapolate, to attribute —in this case—to the very small the kind of behaviour that is common sense when one talks of objects of large or ordinary size. That, for example, if a particle crosses a flat screen with two holes in it, it must have gone through one to the exclusion of the other. This is not true of an electron.

The quantum theory stresses another point which is fundamental to the modern view of physics—the importance of the observer. An experiment to be any use must be observed. True, the immediate observer may be a photographic plate which forms a latent image to be developed and examined later, but there must be something. In other words, the scientist can only learn about the world through his senses. Theories are meant to unify sensations and in this sense explain them, but on these sensations they ultimately rest.

The observer first received proper attention in the theory of relativity. As long as there was supposed to be an ether there was a privileged observer, or class of observers, those at rest with respect to it. Without it all are on the same footing, and equally entitled to be considered. Now relativity asserts that the laws can be stated so as to be the same in form for all, no privilege is allowed.

DETERMINISM AND PREDICTABILITY

But relativistic observers, those rather strange creatures who go about with clocks and measuring rods making signals, are not supposed to alter what they observe. The quantum observer does. Or more precisely the circumstances that attend, observation, for example the light that is required, alter that which is observed and in a manner which cannot be determined even after the observation has been made. In consequence the knowledge that can be acquired is limited, because each observation upsets something else one would like to know. This was the first real hint that there are definite limits to scientific knowledge, limits not dependent on human patience or ingenuity. The argument depends, as all physicists know, on the finite size of Planck's quantum of action, but a very similar conclusion might have been reached before the quantum theory was thought of.

I think it is curious that physics remained deterministic in philosophy as long as it did. The power of accurate prediction in all systems diminishes with time. Even for the planets, those most orderly of creatures, a Nautical Almanack drawn up for the year 10,000 would be appreciably less accurate than one for next year. When one is interested in individual atoms this loss of accuracy can be enormous and catastrophic. Quite apart from any quantum considerations, even if one knew the positions and velocity of every molecule of a small sample of gas at one instant one would not predict the path of a special molecule distinguished, for example, by being radioactive; one could not find, let us say, where it would first hit a wall of the vessel holding the gas. Even supposing every gaseous collision fully determinate a small error in an original measurement mounts up, as Max Born has pointed out, with enormous speed. In a small fraction of a second all the detailed information is useless, and one can only treat the motion as one of diffusion to which only a probability answer is possible. So when time is taken into account one gets much the same result even if Planck's constant were many orders of magnitude less than it is. This kind of virtual indeterminacy is inherent in Maxwell's kinetic theory. It sets as real a limit to certain kinds of human knowledge, even given any thinkable extension of human skill, as does the quantum theory. The circumstances to which it applies are almost certainly of more human importance. The further ahead a prediction is made the less certain it becomes, and beyond a certain rough limit all that can be affirmed is a probability, often over a wide range of possibilities. It is an interesting question, for example, what is the best that could ever possibly be done in the long range forecasting of weather. Can, say, a prediction of the weather on a particular day ten years hence ever have any validity?

Yet in some respects atoms behave in a surprisingly straightforward way. They pile together almost like spheres, like tennis balls in fact. They are slightly compressible and their distances depend a bit on chemical relationship, but one can place them in order in molecules and still more definitely in crystals. The work which is being done by the group at Cambridge under Perutz and Kendrew is a striking example of this. They have located most of the 10,000 atoms in the vastly complicated molecule of haemoglobin, the first protein for which this has been done.

Single rows of atoms, and occasionally individual atoms, can actually be seen in the electron microscope. They seem as real, and almost as commonplace, as grains of sand.

In contrast to this matter-of-fact behaviour of atoms the electrons are strange fairylike creatures. They have no particular place; even when part of an atom one can at best assign them a region in which they are most likely to be found. Unless they have an unusual amount of energy they cannot be assigned a definite path. Even their approximate behaviour is queer and to treat them properly requires highly abstract mathematics.

They can be created out of the energy of radiation but only in pairs with positive and negative charges, and the positive one soon dies in a suicide pact with another negative. In the same way protons and antiprons can be created and disappear. Certainly other kinds of elementary particles also have their antiparticles.

I should like to conclude by referring to two ideas of a somewhat more speculative character which may prove of importance in general thought.

The first is the relation between mass, energy, and matter. In conventional mechanics mass is the primary property of matter, even more so perhaps than

extension since it is more constant. Now, as you know, the theory of relativity made it probable that mass is energy considered from another point of view. This is expressed by Einstein's famous equation $E=mc^2$. Thus if energy is added to, or taken from, an otherwise closed system the mass of the system will increase or decrease, as the case may be, though it takes a lot of energy to make much difference to the mass. Einstein's conclusion has been abundantly confirmed by the discovery of nuclear energy and other experiments in nuclear physics. Further, as I have just said, energy can be transformed into pairs of particles of opposite sign. It began to look as if matter is just another name for energy.

SUB-ATOMIC PARTICLES

It may seem paradoxical to equate energy with the property, mass, that measures inertia, but remember that in Newtonian mechanics the bullet penetrates because of its inertia which makes it continue in its state of motion. However, mass is only one property of matter and perhaps not even the most important. There are indications, rather slight perhaps, but not to be ignored, that matter is not just another name for energy. The study of the many curious particles which have been found in cosmic rays and later produced in the giant so-called "atom-smashers" has shown the persistence of certain features in spite of the bewildering number of spontaneous changes which these particles undergo. Two groups of these particles have appeared such that the net number in each group remains always the same, and this in contrast to a third group for which there is no such constancy. By the phase "net number" is meant the difference, in each case, between the numbers of the "ordinary" particles and of the antiparticles. Thus electrons are a member of one group called "leptons", to which neutrinos also belong. In reckoning the net number of electrons one subtracts the number of positrons from the number of ordinary electrons. Thus the creation of an electron-positron pair does not alter the net number. The rule states that no interaction between particles of any kind, including the photons of radiant energy and the mesons of the cosmic rays, can altar the *sum* of the *net numbers* of the three kinds of particles, electrons, neutrinos and μ mesons, which count as leptons. A similar rule holds for the class of particles, protons, neutrons, and some others, which rank as "baryons". Leptons can never change into baryons or reversely.

This seems a hint that underlying matter are two classes of entity, each of which indeed can appear in several different forms associated with various amounts of mass, sometimes electrically charged and sometimes not, but yet fundamentally the same. Matter is, I think, more than merely mass or energy. A neutrino has zero rest mass but yet is an entity. A piece of ordinary matter is made up of leptons and baryons in fixed numbers.

The mass of an atom at rest is a form of energy, but matter may be something extra.

NATURE LIKES WHOLE NUMBERS

This leads to one more instance of broad ideas derived from physics, my last. It is one of the strangest facts of Nature that she is so fond of whole numbers. The mere existence of large classes of individuals identical in each class such as electrons, protons, atoms of flourine, molecules of ethyl alcohol and many more is surprising enough. One might expect a continuous gradation of sizes, weights and charges. But it is not so. On the smallest scale only certain types of particles exist. The next most complicated things, atoms, are built of integral numbers of electrons, protons and neutrons. The numbers are fundamental and characteristic. An atom of carbon is a pattern based on the number six, there are six electrons, six protons, and six, seven, or eight neutrons according to which of the three kinds of carbon atom it happens to be.

This is such a commonplace of science that one is apt to take it for granted. But surely this, and similar facts about other atoms, are most startling if one thinks. Further, the details of the pattern made by the electrons depend on another set of small integers, the quantum numbers. We cannot say yet whether this is also true of the arrangement of protons and neutrons in the nucleus, but there are indications that it may be. We are getting back to one of the earliest scientific ideas. Pythagoras taught that whole numbers are supreme.

It is worth notice that the masses of the atoms, even reckoned at rest and in the lowest energy state, show only rough regularities. The energy of formation and the mass representing it is variable and, though energy is sometimes divided into units, there is here a continuous variation, for the unit is $h\nu$ and ν can have any value. Yet even here we have units in a sense and all photons of the same frequency have the same energy.

Molecules again are composed each of an integral number of atoms. It is true that at the moment of a reaction it may be difficult to say which atoms belong to a molecule or even if the concept of molecule is valid, but few would deny its importance in general. It is a concept which, though it owes something to the desire of the human mind to simplify, yet arises almost inevitably from nature. If the Martians are competent chemists they will, sometimes at least, think in terms of molecules.

Rather the same can be said of the concept of a cell. Living matter is generally speaking cellular, and the cells that compose a given kind of tissue are mostly pretty much alike in size and shape. Even the organisms that they form tend, at least, to fall into species each containing very many similar individuals. In many cases also the component parts of an individual are multiplied, for example, scales or leaves.

THE "ATOMICITY" OF THINGS

While the "atomicity" of electrons is perfect in the sense that each is in principle indistinguishable from any other, and the possibility of exchange without resulting differences is built into the theory, the atomicity of members of a species, of cells, and even of molecules is less rigid, but concepts embodying it are highly useful and represent something real in the world.

At present one can only speculate as to how far the complete atomicity of the elementary particle causes the partial atomicity one sees in biology, or for that matter in astronomy. If it is *not* a sufficient explanation then we must look even deeper than the elementary particles for this principle of atomicity, which would make it fundamental indeed.

It is surely something for beings, so utterly insignificant compared with the smallest of the stars that are scattered with reckless abandonment in the heavens, to be able to understand some at least of the principles which control their existence and enable us to perceive them.

To see these principles as applying equally on earth, as manifest in the most varied phenomena: in the motions of the tides, in the blue of the sky, in the lightning flash, and in the falling apple: to prove our understanding by creating, on however small a scale, compositions of our own which use these principles in new ways of our own devising: to be beginning to see some light on the nature of living matter and how living forms can transmit themselves to descendants, all these are worth while and worthy to rank with the achievements of sculpture, of music or of literature.

Science is not merely the control but also the understanding of nature. Its two aspects must be held in equal honour.

SCIENCE AND TECHNOLOGY IN ANCIENT MEXICO

IRENE NICHOLSON

It has long been known that pre-Columbian Indians had considerable astronomical knowledge. Recent studies show that the wheel, the arch, and other technical developments were known to them.

What stage of scientific development had the Indians of ancient Mexico reached before Europe knew of them? Until recently it seemed unlikely that they had any knowledge worthy of so exalted a name. Men who had discovered neither the wheel nor the true arch could scarcely be considered competent even as technicians. Now, ancient Mexican toys on wheels have been found; and at least one true arch is said to exist among the temples of Yucatán. Apparently these discoveries were not put to much practical use; but the fact remains that they were known, and this radically changes our ideas about Mesoamerica.

Moreover, western research into hallucinogenic drugs obtained from mushrooms and cacti (*peyote, mezcalin,* the mushrooms *Psilocybe cubensis* and *Stropharia*) has revealed that ancient Mexicans knew how to manipulate psychological states by specific chemical substances. Other practices which seem at first sight to be based on magic or superstition—such as the burning of copal to induce rain—also appear on closer scrutiny to rest on sound scientific bases.

It has long been known that the pre-Columbian Indians had considerable astronomical knowledge. Recent studies on the Aztec and Maya calendars have yielded more information. The old calendars were not only accurate; they were based upon a detailed knowledge of the heavens unknown in Europe until much later.

Studies of agriculture and plant life have raised intriguing questions as to the origins of the peoples of the Americas. If the mystery of their origins could be solved, perhaps the source of the scientific knowledge they possessed might also be established, together with the historical reasons for some of the strange omissions or negligences.

Scientific thought in ancient Mexico shows one special characteristic differentiating it from western science. It is a characteristic which may explain why some technical developments were spurned. Science and religion were complementary and not mutually exclusive. All knowledge, even knowledge attached to economics, to sport, and to mere pleasure (if such a frivolous concept existed, which is doubtful), was god-given. Chemistry served psychology; psychology could be manipulated for the sublime purpose of reaching closer to the gods. Astronomy not only helped man to take count of his cycles of time, his seasons, his planting and his reaping; it could also describe the divine order ruling in the heavens.

THE RAIN MAKERS

Burn copal and rubber, and invoke rain. The practice looks like a clear case of superstition. Yet in 1958 Dr Florence W. van Straten of the U.S. Navy Department suggested sowing clouds with soot, a method which she thought offered certain advantages over the earlier use of ice for inducing rain. The dry-ice method can function only at low temperatures. But clouds are often warm, and it seemed to Dr van Straten that moisture might be made to fall if some drops were heated more than others. Carbon soot has the property of accumulating radiant heat. When particles of soot are sprinkled on to a cloud, any drops of moisture that happen to capture one soot particle or more will be warmed by the absorption of sunlight and will lose their humidity by evaporation; whereas the drops that remain unsullied will maintain their cold temperature and will fall through the cloud until they join other drops and thus grow to a sufficient size to precipitate. In each of seven experiments, about 2 lb. of soot were dropped from an aeroplane on to a cloud. Taking from 2½ to 20 minutes, the cloud precipitated.

If soot is dropped in a humid atmosphere but without cloud, the effect is just the opposite. The black particles capture sunlight and warm the air. The warm air rises, expands, and cools. One part of the moisture condenses, and a new white cloud appears in the sky.

Let us turn again to the ancient Mexicans, and imagine the priests on mountain peaks, in a cloudy atmosphere, burning magic balls of rubber latex and copal to bring rain to their crops. They use a brazier modelled—comically, it seems to us—with the head of the god. In the midst of the incense is placed a jade bead to represent the idea of divinity combined with the greenness of the earth. Above the brazier is a clay hood, formed like the inverted bowl of the sky, which captures the soot and disperses it. How much of the theory of their actions the priests knew, we can only conjecture; but they must have known from experience that the ritual was effective. Even so, success depended ultimately upon the gods. The scientific act was fused with a religious one.

Commenting on the practice of rain making, and suggesting that the priests may have known how to take advantage of favourable winds to send their clouds scudding in the directions desired, Carmen Cook de Leonard points out that god-like attributes may well have been accorded to the dispensers of magic rituals. Which is the more likely? That

FIG. 1. The rain god, Tlaloc, holding his lightning serpent and thunder axe. In front of him is a small temple from the roof of which the maize plant grows. Within the temple is the offering of a ball of rubber and copal incense. The spots on the garment of the god are made from drops of liquid rubber, *c.* 1500.
Codex Vaticanus 3733, p. 45. Vatican Library. (From the Duc de Loubat edition, 1902.)
(Photo: C. A. Burland)

these men believed in their own divine powers? Or that they knew the mechanism?

AGRICULTURE

If the wise men knew how to control moisture and bring rain, they possessed the secret of controlled agriculture. From carbon-14 datings it appears that maize was cultivated in Mexican territories about eight or nine thousand years ago. The dates are provisional, but cultivation of maize was certainly an ancient practice, and beans, sweet potatoes, and pumpkins were also cultivated from about the same period.

Cotton is a puzzle. In Peru (and therefore possibly in Mexico) it has been found to date from 3000 B.C. Yet Prof. George Carter claims that New World domesticated cotton contains twice as many chromosomes as other cottons, and that half these chromosomes are of Old World, half of New World type. Old World cotton, he suggests, was introduced into the New World at some remote period, so that the "discovery" of America by Columbus should properly be called *re*-discovery. If so, at what date before 1492 was the New World known to the Old, and how was the knowledge lost? Or was it known only to certain peoples? Those who, according to one theory, are supposed to have crossed the Behring Straits from Asia? Or those who may have traded in either or both directions across the south Pacific, using the Polynesian islands as stepping stones? Carter thinks, for example, that maize may have been carried by man across the Pacific in quite early times. He thinks that this cereal, usually thought to be American in origin, may be either African or Asiatic.*

* It has recently been suggested that Arab ships from West Africa visited the north Brazilian coast in the 12th century and may have brought back specimens of maize.

Leaving aside the controversies over cotton and maize, there are other native crops sufficient to suggest that American agriculture developed independently. These include chilli, tomato, avocado pear, yucca, cocoa, peanuts, tobacco, copal, vanilla, and also many fruits such as the guayava, papaya, and pineapple.

At the very latest by 2000 B.C. agriculture must have been established. Irrigation was known, especially on the high plateau, and its existence would have implied some form of co-operation and social control. The primitive, wasteful, "cut and burn" methods of the Maya lands and of the Veracruz and Tabasco tropics would have allowed only one-sixth of the available land to be cultivated at one time. In the highlands, with irrigation, the land in use could have doubled at least. Oddly, it looks as if civilisation arose first in the lowlands, with a "cut and burn" agriculture. If so, Mexico is the only known region where such a phenomenon occurred.†

The highlands had fairly advanced systems of water collection and of irrigation. At the time of the conquest, and for some period before, artificial islands had been built in the lakes of the ancient Mexican capital, Tenochtitlán. They were humid at their base, and enriched with lake mud that could act as a natural manure. They were, therefore, excellent crop lands.

Complicated water-storage facilities were available on the high plateau from at least the year 1418, when an aqueduct was constructed in Tenochtitlán. Its baked clay eroded, but it was replaced in 1465 by another which lasted

† According to some authorities, the first maize comes from the drier north-western part of Mexico, and it may well be that the "slash and burn" technique developed later when attempts were made to bring maize cultivation to the forest lands of the south.

until well after the conquest. In the nearby "republic" of Cholula there was a water-distributing duct made in a single piece, with very thick walls and with an inner diameter of about a man's height. Remains of this aqueduct were discovered in 1868, and appear to have been in use well into the 16th century.

PAPER MAKING

The baking of a long clay tube of such a size would present formidable technical problems, but pottery of all kinds, except that made on the potter's wheel, was of course extensively practised. Among other crafts were weaving, gold beating, feather work, and paper making.

One of the early chroniclers, Pedro Mártir, tells how "they write on leaves of a certain thin inner bark of the trees, which is cultivated beneath the outer bark and which I believe is called 'philira' . . . a hard material separates the outer layers in the manner of nets with holes and thin meshes, and this they fill with strong gum. . . ."

Bernal Díaz de Castillo describes "little booklets of a paper made from the bark of a tree, which they call *amatl* (Mexican fig) . . ." and Fray Diego de Landa tells us "... this paper they make from the roots of a tree, and they give it a white lustre upon which one can write."

Boturini describes the manufacture of paper from maguey. The long thorns were set to rot, and the resulting thread (the henequén or sisal of modern times) was washed to soften the fibre, which was then stretched and varnished.

Frederick Starr describes how, as late as 1898, he found the art of paper making still surviving among the Otomí Indians of the states of Hidalgo and Puebla. They used two kinds of bark, *moral,* which gave a whitish paper, and *xalama* which was mauve.

Paper was used in ancient Mexico for religious ceremonies, as a basis for feather work, and in the making of clothes and other articles besides books. Tributes were sometimes paid in paper.

MEDICINE, SURGERY, AND PHARMACY

Mexican rural doctors still fight a sometimes losing battle against the *curanderos,* herbalists or witch doctors. In every village market there is at least one stall selling a variety of roots and grasses upon which it is impossible to get precise information. Either the stall-holder does not know, or will not say. "Against bile", "good for the stomach", "good for all illness". Much herbal and medical knowledge must still exist, but to discover the *curanderos'* secrets it would be necessary to gain the confidence of the families who have practised the art for generations as a closed monopoly.

The specific uses of some alkaloid-producing plants native to the Americas became known to Europeans relatively soon after the conquest. Tobacco and quinine are examples. Others, such as the narcotic mushrooms, *peyotl,* and *mezcal,* are only now being fully investigated. Many more such plants probably exist with psychological or therapeutic properties, and the pharmacopoeia compiled by friars and scientists during the two centuries after the conquest might, if studied, yield hitherto unknown miracle drugs. It is surprising that the lentil-like seed called *Ololiuhqui* (*Ipomoea sidaefolia*), which was deified in ancient times together with *peyotl,* and was used to stimulate powers of divination, seems not to have been analysed chemically.

In the mid-16th century a Seville doctor, Nicolás Monardes, studied the properties of some American drugs, although he himself never visited the New World. He found that sarsaparilla was most effective, whether as a general purifier and sweat-inducer or as a specific against syphilis or scrofula, when administered according to ancient Mexican custom. The heated juice of the root was taken morning and night, the patient fasting the while and submitting to a two-hour sweat bath two hours after each dose.

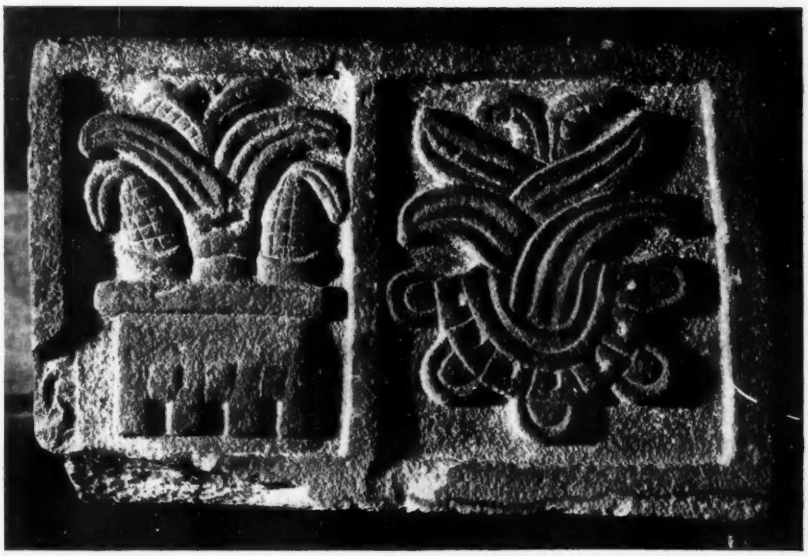

FIG. 2. The deified maize plant. On the right is the young plant adorned with a jewelled necklace. It is the goddess Xilonen at this stage. On the left, the maize is ripe for collecting and is placed on a throne. It is now known as the goddess Chicome Coatl. From an Aztec carving, *c.* 1500, in the National Museum, Mexico. *(Photo: C. A. Burland)*

FIG. 3 (*above*). A pottery incensario for holding balls of copal and rubber incense. This was held by the priests and waved before the images of the gods, and sometimes as an elaborate compliment, before distinguished visitors to the temple. The black smoke of rubber incense was thought to represent the black rain-clouds.
(*British Museum photograph*)

Later in Antwerp the botanist Carolus Clusius published a three-volume work on American drugs entitled *De simplicibus medicamentis ex occidentali India delatis* and *Simplicium medicamentorum ex novo orbe delatorum . . . historiae liber tertius.*

Towards the end of the 16th century, Philip II of Spain ordered his physician Francisco Hernández to compile a list of Mexican remedies. The result was 24 volumes, listing 1200 plants, of which 400 were medicinal. There were ten further volumes of illustrations, and one zoological atlas. This formidable work was shortened by the Neapolitan Leonardo Recci and published in 1628 under the title *Rerum medicarum Novae Hispaniae Thesaurus.*

Hernández was surprised to find that the native names of plants implied a guide to classification, properties, mode of use, and origin. European botanists, including Linnaeus, accepted many of these ancient classifications as correct. Cucurbitaceous and sapotaceous plants and the genus *Agave* are examples.

Surgical practice relied considerably on pharmaceutical knowledge. Eighteenth-century European surgeons, dreaming that some day they might find a haemostatic substance effective against internal haemorrhage, would have been astonished to know that at least thirty-four such substances had been identified and used by ancient Mexicans. Gangrene was effectively treated with *Helianthus glutinosus.* The swelling of abscesses was reduced by applying various juices or chalk mixed with tobacco. If the abscess became very troublesome it was incised, washed with urine, and covered with a poultice of tar and feather, the latter acting in the same way as a cotton-wool padding.

Tumours (the differential diagnosis as between malignant and non-malignant was known) were treated by feeding newts to the unfortunate patient, or by external application of the mashed heart of the fruit of the *yoyotli.* This fruit contains a poisonous oil which produces violent vomiting, respiratory fatigue, and paralysis of the heart. It has been used as a substitute for digitalis but is exceedingly dangerous. Popularly it is applied externally against haemorrhoids, and internally to cure snake bites.

FIG. 4 (*below*). Aztec astronomical symbols. At the side of this stela the planets are shown as winged eyes, alternating with pendant symbols for stars. In the centre, the diving eagle of the setting Sun is followed by a god (possibly Piltzintecuhtli, Mercury) and by an owl carrying a jewelled girdle, probably the planet Venus. National Museum, Mexico.

Wounds were treated with salt or charcoal and sealed off from air. Nose wounds were sutured with hair to which honey and salt had been applied, and lip wounds were treated with liquid rubber. Plastic surgery was known, and artificial noses were sometimes made. Pyrite and jadeite tooth fillings have been found in excavated skulls. There were many forms of treatment for eye diseases, and a kind of collyrium existed in the juice of a chicory-like plant called *chichicaquilitl* (*Sonchus siliatus*). A substance for contracting the uterus, as a general treatment in the late stages of pregnancy, is still used by peasants: *cihuapatli* (*Ericoma floribunda*).

ASTRONOMY

Whereas our own calendar measures only the passage of the Earth about the Sun and the Moon about the Earth, the Mayan and Aztec calendars took note, also, of the movements of the other planets in the solar system, and possibly even of the solar system within the galaxy. This breadth of measurement was achieved by various sliding scales. The Maya used no fractions other than a half-day, but by adjustments to the time count they achieved a calendar of which the average year was 365 days 5 hr. 48 min. 28·8 sec., which gives an error of 3 days in 10,000 years. This is as accurate as the Gregorian calendar adopted in 1582, when October 5 became October 15 in order to correct an accumulated discrepancy. The Mayan figure is thought to have been calculated about the 6th or 7th century A.D.

The Mexican calendar wheel (which is quite distinct from the Maya system) was measured in 52-year cycles. Within this period cycles of 13, 18, 20, 73, and 260 days made complicated sliding combinations. The 13-day cycle (called *Companions of the Day*), when multiplied by that of 20 days, made a 260-day cycle known as *Tonalpohualli;* 73, multiplied by 260 made 52 years. There were also lesser 9-day cycles known as *Companions of the Night*. The 20-day measure combined, in turn, with that of 18 days to make 360 days. The extra 5 days in the year were considered to be outside the calendar because they did not fit into the sequence of 20-day periods. They were, therefore, observed as fast days in which people performed no creative work until a festival ushered in the New Year. At the end of the 52-year cycles an extra inter-calary period alternately of 12 and 13 days brought the calendar in line with the position of the Sun among the stars. There were four types of day after which the year was named. There is evidence to show that the "Year Name Days" were very rarely the first day of the year, but were employed much in the sense of ordinal numbers—of course with a magical significance.

The reasons for the choice of these particular time-lapses are being studied by many workers. Raúl Noriega and others, for instance, are finding interesting data relating to eclipses of the Moon. Noriega has done vast numbers of computations, and it is enough to point out here that in 5 periods of 260 days, that is, in 1300 days, the Moon circles the Earth 44 times. Mercury's cycle is 116 days, or about 9×13, and 20·5×260 gives 46 cycles, or 5330 days. The cycle of Venus is 584 days, or 8×73, or 2·25×260. One cycle of Mars is 780 days, or exactly 3×260. Jupiter's cycle is 399 days, roughly 22×18; 73 cycles of Jupiter make 28,120 days, or 260×112. Saturn's cycle is 378 days, or 360 plus 18, and 11 cycles are 4160 days, or 260×16. Thus the cycles of all these planets could be calculated more or less accurately by the various time measurements contained in the sliding scale. Raúl Noriega has been able to show that the symbols on the famous "Aztec Calendar Stone" in the National Museum in Mexico could be used to calculate solar eclipses in four interwoven groups, both forward and backwards in time for unlimited periods with an accuracy of one day in the Mexican system.

In London Cottie Burland has been doing similar work on the Venus periods in the ancient Mexican calendar, and has shown that the first record of an observed transit of Venus comes from the ancient Pipil site at Santa Lucia Cotzumahualpa where the transit of November 24, A.D. 416 was recorded in Toltec-style calendrical symbols on a stela. Similarly at the Mexican site of Xochicalco ("In the House of Flowers") an inscription records the inferior conjunction of Venus in March A.D. 480. Recent carbon-14 determinations from material found at Xochicalco have given a date of within half a century of A.D. 450.

The Mayas measured larger units not in centuries, but (starting from an 18-day period) in multiples of 20. Thus 20 times 18 were 360 days, making—with the 5 days outside the calendar—1 year. This was a *tun*. A *katún* of 20×360 days was 7200 days (roughly 20 years and exactly 12¾ cycles of Venus). A *baktún* was composed of 20 *katunes*, or 144,000 days (approximately 400 years). A *pictún* was 20 *baktunes* or 2,880,000 days (about 8000 years). A *calabtún* was 20 *pictunes* or 57,600,000 days (about 158,000 years). A *kinchultún* was 20 *calabtunes* or 1,152,000,000 days (about 3 million years). Manageable units were thus available for up to 3 million years, which seems to suggest either a very long history, or the ability to forecast accurately the positions of the heavenly bodies over very long periods.

As Carmen Cook de Leonard says, the religious systems of ancient Mexico appear to have been dependent upon physical experiences received in states of exaltation. The sciences, among them astronomy and medicine, constantly verified these results and corrected their numerology or their methods. Astronomy was at the service of religion, and religion in turn served medicine. As a corollary, the evidently insatiable desire of the Mexican peoples of ancient times for profound religious, poetic, and other mystical experiences, was in itself a kind of gadfly prodding science to exact calculations of astronomical formulae. On the other hand, any scientific achievement that appeared unrelated to religion must have been looked upon with disfavour. Awe was an experience well within the emotional capacity of these Indian peoples, and their knowledge of astronomy only supported, and did not contradict, their profound sense of the mystery of the heavens. Indeed, as we study this ancient civilisation, we are brought back again and again to Fred Hoyle's conviction that awe is present in all men when they contemplate the mysterious order of the galaxies.

SEA TEMPERATURE DIFFERENCES

J. H. M. SYKES

In tropical zones the sea is much colder at the bottom than it is on the surface. This difference of temperatures represents potential energy awaiting exploitation.

The literature concerned with the generation of power from new sources is in a particularly ebullient state at the present time. We hear of new sources of power such as energy created directly from nuclear reaction, of new ways of capturing the energy of the Sun, and of extensions of the more conventional methods such as harnessing the tides and developing the potential of windmills.

One of the most fascinating methods of energy production, as yet untried in the commercial sense, is that of exploiting the difference between the temperatures of the sea at the surface and on the bottom in tropical zones. This was a scheme envisaged over a hundred years ago by Jules Verne, whose forecasts in so many fields of mechanical science have come true in recent years. Before his death in 1905 this remarkable precursor of the science fiction writing corps had predicted the submarine in its present form, the long distance transatlantic aircraft, and, indeed, a very large number of the applications of science which we now take for granted; but we are here concerned with his proposal made in "Twenty Thousand Leagues under the Sea" where Jules Verne definitely proposed that mankind should endeavour to utilise the energy stored by the Sun in the superficial layers of the sea, by relating it in some way to the cold water (whose temperature remained sensibly constant at all latitudes) in the ocean depths.

In 1926, M. Georges Claude put forward, together with M. Boucherot, a proposal based on the Carnot cycle for a practical scheme for utilising this sea temperature difference. Basically, the scheme is simple. It is well known that water will boil at a lower temperature at the top of a mountain than at sea-level. At the summit of Mont Blanc water boils at 70°C (instead of 100°C in normal altitudes). This is due to the difference in barometric pressure in the two localities. Obviously, if the pressure is reduced further, water will boil at ambient temperature.

Suppose now that one has available a source of warm water that is led into a chamber which is continually exhausted. The water will instantly "boil". Imagine now that the vapour is passed to a chamber in which cold water is available: it will at once condense back to water. If the blades of a turbine are so situated that the vapour, in its passage from the exhausting chamber to the condensing chamber, must strike these blades, then the turbine will be driven round and could generate power.

CLAUDE AND BOUCHEROT

This is the basic scheme envisaged by MM. Claude and Boucherot. The warm water from the surface of the tropical ocean would be drawn through piping into a large chamber in which it would be subjected to a vacuum; and on a relatively large evaporating surface it would at once change its state to that of a vapour and would be sucked down through the blades of a large turbine wheel into the condensing area, where it would meet the cold water pumped from the bottom of the sea. In doing so it would turn the turbine blades, which would be of the reaction type, and would drive the alternator mounted at the top of the turbine shaft.

Claude, after outlining this scheme in 1926 and proving its practicability by means of a model, carried out a prototype installation on an industrial scale at Ougrée-Marihaye, near Liège. With a temperature difference of 20°C, the turbine was made to operate satisfactorily. In 1928 the principle was demonstrated to the *Académie des Sciences.*

A little later Claude tried out an installation in Cuba in the Bay of Matanzas, and at once encountered the major difficulty which will always be associated with practical realisations of this scheme. The volume of water needed, with the relatively small temperature difference and basic energy content, is obviously very large if any significant amount of power is to be expected from the turbine (the difference is, in fact, between about 28°C for the surface temperature and 8°C for the deep-water temperature). Thus the pipe which sucks up the cold water, and which has to be laid downwards and so on to the sea bottom must be of very large diameter. In the experiments at Cuba, Claude used a pipe 2 m. in diameter, and this pipe had to be 2000 m. long. Twice the pipe was broken, and very considerable efforts were needed eventually to submerge it to the required depths.

THE *TUNISIE*

A scheme for a much larger installation was not considered practicable at that time, not because of technical difficulties but because of the economic problems relating to the initial cost of the installation, which was greater per kW output than for any other form of energy production.

Claude did not give up after he had initially failed to secure funds for a continuance of his experiments in Cuba. He secured a ship, the *Tunisie,* and hoped to turn her into a floating power station. The two vital elements in this shipboard installation were a tube 700 m. long, which could be supported at the upper end by means of a very large float (9 m. in diameter) and would be anchored by a caisson sunk to the bottom of the ocean, and a huge cylinder on board ship 25 m. long and 6 m. in diameter, which would contain the evaporating, generating, and condensing plant.

During trials with this remarkable ship, in 1935, the caisson intended to anchor the lower part of the suction pipe to the ocean bed broke away as the tube was being lowered section by section. As this would have left the

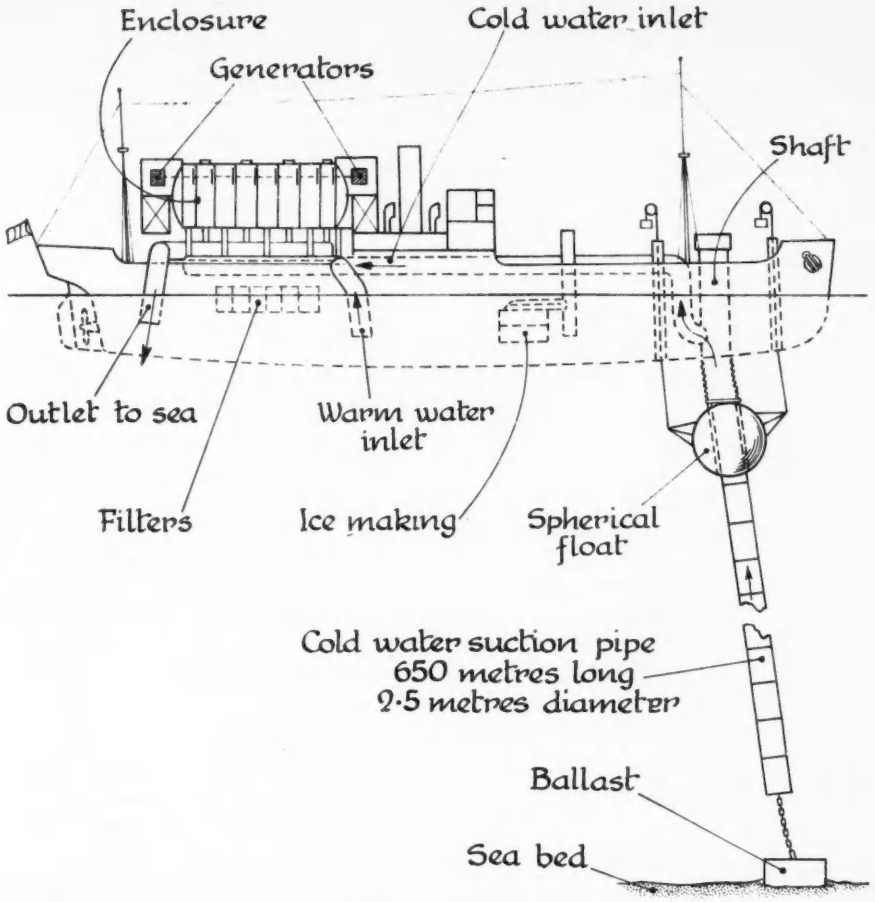

FIG. 1. The *Tunisie*, a courageous but ill-fated attempt to build a floating power station. Warm water drawn in at the surface was to boil in an evacuated chamber, then turn a turbine as it passed through it to a condenser at a still lower pressure. To maintain the low pressure needed at the turbine exhaust to make the system work, the vapour was to be condensed by using cold water drawn from the ocean bottom and then pumped overboard. The turbine was directly coupled to electric generators.

enormous float unanchored, and a danger to navigation, Claude regretfully blew up the float with dynamite, and the whole experiment had to be abandoned.

However, France has always been the home of engineers attracted by the solution of unusual problems in civil engineering, as evidenced by the remarkable achievements of her engineers in thin arch dams, bridges, and the like. This problem of extracting energy from sea temperature differences was furthermore of special interest in France since many of her overseas territories with tropical seaboards had need of electrical energy in "packets" of relatively small size. Although hydro-electric installations could be and have been built in such territories, it is often impracticable to build a small hydro-electric plant, since the adduction of sufficient water to the reservoir means the building of a large dam, whether or not the whole potential output is needed by the power station. Generators for exploiting sea temperature differences could, in theory, be built in any convenient size.

THE ABIDJAN SCHEME

The first practicable proposal after Claude's courageous experimental work was put forward in 1950 at the World Power Conference by MM. Beau and Nizery, who suggested that two 3500-kW units be installed at Abidjan on the Ivory Coast at about 4 km. from the beach. This was a particularly favourable location since there was a very deep trough in the ocean bed reaching a depth of 400 m. (1300 ft.). The territory, moreover, needed additional energy resources. Although the decision was taken in 1935 to build a hydro-electric plant, as it cost less than the sea-temperature-difference scheme, Electricité de France have recently announced that when the load has grown beyond the capacity of this installation and the older steam power plants, the Usine Thermique des Mers will be built to give the additional energy needed by industrial development.

The proposals outlined in the 1950 paper have not been sensibly changed in the most recent plans, which the author of the present notes has discussed with engineers of Electricité de France in recent years. In addition to the Abidjan installation, French engineers have also been asked to prepare a project for Guadeloupe, which relates to a similar scheme to that proposed for Abidjan; and it is possible that the Guadeloupe installation might be constructed before that originally proposed for the Ivory Coast.

The Abidjan scheme envisages, as mentioned previously, two 3500-kW turbines; and the first point to realise is that for the total output of 7000 kW, the water flow necessary for the temperature difference of 20°C would be very large and would reach 10 cu. m./sec. while the pipeline would have to be 400 m. (1300 ft.) long and 2·50 m. (8 ft.) in diameter.

The construction of the intake pipe was appreciated as being among the greatest problems; there was also the allied difficulty of sinking it on the sea bed, and considerable experimental work was carried out by means of floats attached to the pipeline which were gradually filled

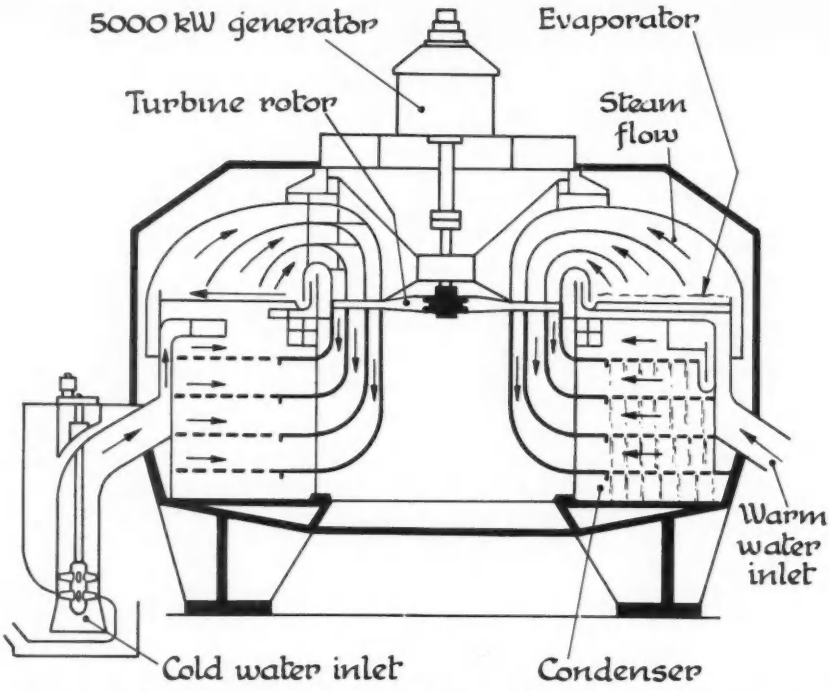

FIG. 2. A cross-sectional diagram of one of the 3500-kW Abidjan turbines. The evaporating surfaces are located above the huge 26-ft. turbine wheel and the condensers below it. The pump which eliminates the condensed vapour and maintains the vacuum in the system is not shown.

with water to allow them to sink with it, under control, to the bottom of the sea, where they would be automatically released.

Many different constructional problems were solved during these tests, particularly those relating to the degree of flexibility needed under the action of waves, and the nature of the forces due to tidal variations and storm water on this very large flexible pipe. French engineers are convinced that these tests, and subsequent experimental work at Abidjan in 1955 and 1956 have solved this problem, so that they are confident that either the Abidjan or the Guadeloupe installations could be satisfactorily carried out from the technical point of view.

As an addition to the natural warmth of the surface water, the Abidjan scheme envisages the use of shallow lagoons in the neighbourhood of the power station, where the warm water from the ocean would be still further heated by the tropical sun, thus increasing by as much as 2°C the vital temperature difference between it and the cold water from the depths of the ocean.

Both the cold water, taken from a depth of 420 m., and the warm water from the surface are known to contain considerable volumes of dissolved gases, and so the scheme includes degasifying devices for both pipelines.

ADVANTAGES

The advantages of the scheme for generating power from sea temperature differences are, to a large extent, parallel to those of hydro-electric plants: the initial cost is high but the running cost is negligible, and there is no likelihood of obsolescence. There are, in addition, two other advantages. M. Beau, in a paper presented to the Société Hydrotechnique de France in 1956, said that the evaporation of sea water could provide valuable chemical by-products and also a form of distilled water. In conversation with the present writer on that occasion M. Beau stressed the fact that—unlike hydro-power, where only the waterfalls actually existing can be harnessed—plants for utilising sea temperature differences are capable of infinite expansion to meet increasing needs. There would be no seasonal or occasional effects such as the droughts which from time to time bedevil hydro-electric projects, however well planned.

The official plans for the Abidjan project follow the lines indicated above, but another French engineer, M. Daric, has put forward a totally different proposal. In his scheme an intermediate fluid is used, and he proposes propane or isobutane as the working fluid. There would be a steel tubular tower, 500 m. high, which would stand vertically in the water, with a control tower above the waves.

The advantages claimed by M. Daric are that the specific volume of water vapour, in the "conventional" sea-temperature-difference scheme, is much higher than with the liquids he proposes: and he further claims that the tower would eliminate the need for the long cold water pipe, which accounts for about 55% of the capital cost of the Abidjan project. The warm water, entering from near the top of the steel tower, would evaporate the propane, and the gas would then drive the turbine. The cold water at the bottom of the tower would reconvert the gaseous propane to liquid form, and a cycle would recommence.

The vision of Jules Verne, that man would harness the enormous energy which the sun prodigiously throws down on the ocean surface, has not yet come true in practical and commercially economic form: but there is little doubt that before long one or other of the two fascinating projects Jules Verne's countrymen have laboured on for so long will come to fruition.

MAN MAKES THE CLOTH: CLOTHES MAKE THE MAN

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The need for protection against the elements, magic, and the requirements of modesty have undoubtedly been important in the development of clothing. Today the physiologist, the chemist, and the dress designer as well determine what we shall wear.

FIG. 1. Knots have been associated for centuries with the magical properties of tightness (which prevented the entry of evil spirits) and looseness (which allowed them to escape). In some cultures, however, knots were loosened for the attainment of good luck. Thus, the ancient customs of untying all knots in the dress of pregnant women, to ensure an easy and safe delivery.

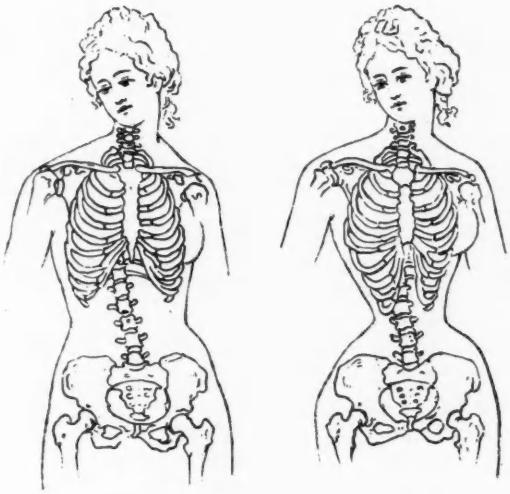


FIG. 2. Spinal deformities, injuries from cracked ribs, and breast tumours are among the diseases suffered by women which were attributed to the wearing of corsets. (Soemmering, 1790.)

The origin of clothing is obscure. Earliest objective evidence is limited to the remnants of woven, dyed cloth which have survived the uniform heat of ancient Egypt, the Neolithic and Bronze-Age cemeteries of Greenland, and the peat bogs of Denmark, Holland, and Germany. Further testimony is derived from the works of the artists of Prehistoric, Classical, and later periods. However, this testimony may have been prejudiced by the imagination or by the demands of magical influence and religious beliefs. The same may also be true for the evidence of the traveller and historian.

We are here not primarily concerned with the "anatomy" or outer trappings of clothing—too well documented to warrant discussion—but rather with its purpose and effects. It is generally accepted that relatively hairless *Homo sapiens* first appeared in the warmer regions of the world, and it may well be that clothing, as we understand it, evolved from a simple ring or girdle around the neck, hips, or elsewhere to which amulets, ornaments, or objects of utility were attached. From such a "tropical garment" loose coverings for the shoulders, trunk, genitals, or buttocks, may have arisen with a cloak (poncho-like) or skirt as final development. Migration to colder climates would have necessitated, for both sexes, close-fitting garments covering the whole body, exemplified by the fur tunic and trousers of the Eskimo. There are, however, many controversial points in such a simple theory.

The more the customs of early civilisations and of primitive people are studied, the clearer it becomes that fear of the unknown has played an important role in the development of clothing. Since devils and magical influences were apparently able to get into the body, a state of "tightness" could keep them out and one of "looseness" enable them to get in. Thus the protection afforded by tight rings and girdles.

THE SHAPE OF THE PAST

The shape of the human body has often been so modified by its covering of clothing as to be unrecognisable. A type of deformity still common among civilised races is that of

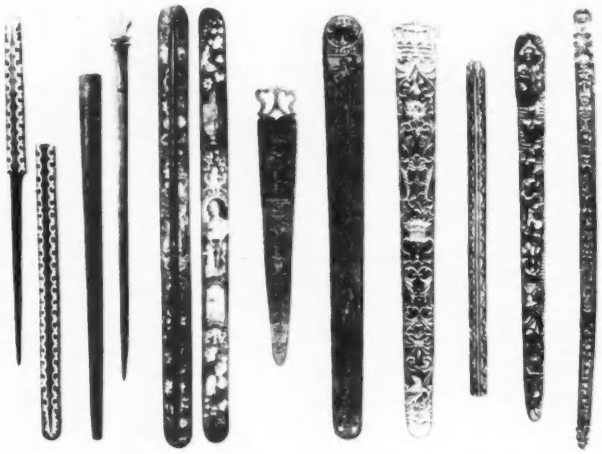


FIG. 3. The early corset was sometimes reinforced with bone or iron busks, some of which were dagger shaped. This collection of 17th- and 18-century busks is from the Cluny Museum in Paris.

FIG. 4. The wasp or weasel waist was achieved by compressing the torso in an iron corset like this one. It is said that Catherine de Medici ordained that all women of good breeding were to compress the waist to an impossible thirteen inches or so.

compression of the abdomen, waist, or bust, or accentuation of the latter, by girdle, bodice, or corset. The last two words are peculiarly related to the torso, for the first is derived from the word *bodies* or *bodys* and the second from the French *corset*, the diminutive of the Old French *cors* or body. The earliest example of waist constriction is that seen in the snake women of Minoan Crete (*circa* 1500 B.C.) clad in a long skirt, with hollow back, and a tight, corset-like girdle but with the breast completely exposed. Like prehistoric Venus, this undoubtedly represents a goddess of nature or fertility. Greek and Roman women sometimes supported the abdomen and bust with bandages resembling puttees, around the loins, the waist, and the bust (*strophion* or *mamillare*), but as the latter bandage had to be fairly tightly applied it was far inferior to the modern shoulder-supported brassière. A corset exaggerating the shape of the bust would hardly have served with the loosely draped garments of Classical periods.

The corset, as understood today, appeared with the "Spanish" fashion of the 16th century. At first an external, laced bodice, it was later reinforced by "busks" of wood or bone and went to the ground as an undergarment. The garment was sometimes made of tin or iron, and, occasionally in the last century, of leather. Its early purpose was to contrict the waist and, strangely enough, to compress and not to accentuate the bust. Commonly associated with the flat bust was the markedly protuberant abdomen, visible except when hidden by the farthingale or *garde-infante*. The meaning of the large abdomen is in some doubt.

In 1793, Soemmering, a German physician, listed some hundred earlier clinicians who had in vain decried against the shackles of the corset. Among diseases of females which, at some time or other, have been ascribed to this undergarment are: abnormal menstruation, miscarriage and breast tumour, injuries from cracked ribs, shortness of breath, fainting and palpitation, spinal deformity, chest complaints, and consumption. Chlorosis (a form of anaemia characterised by a greenish colour of the skin) is now believed to have arisen from the combination of long-continued compression of the body, a ladylike diet lacking in iron, insufficient exercise, and the absence of sunlight from the body which have been the common lot of young women over the last five hundred years. The modern young woman, however, supports the bust and abdomen with foundation garments which few physicians would criticise.

DIRT, FLEAS, AND UNDERWEAR

The history of undergarments is more closely associated with reasoned thought than is that of nudity or outer clothing. A nether undergarment was used by the biblical priests and later by the Romans. During the Middle Ages, undergarments were rarely worn by the peasantry, although the loose smock and trousers ("braies" or breeches) give

FIG. 5. Cretan snake goddesses. This is the earliest example of waist constriction. The exposed breast undoubtedly represents fertility.

the impression of such garments. The relative climatic warmth of the Middle Ages may, perhaps, throw light on the few items of clothing available to the poor during this period. If the magnificent external garments (and sometimes the shirts) of the lords were a measure of earthly possessions, the simple and rarely washed undergarments were more symbolic of the spirit or soul within; for, to appear in church in one's shift was a sign of penance and of humility, and such was the garb sometimes demanded as a sign of surrender in war.

In the middle of the 16th century, Fracastorius taught that even if disease was the work of the devil and of the evil eye, it was also due to "seeds of contagion" which could be held in the clothing of sick people to be passed on to others; but the teachings of the Church and the paucity of baths did not encourage the frequent washing of the body or clothes. The evil smell of most soap substitutes available to the poor (wood-ashes, hemlock, nettles, or cow dung) was itself somewhat of a deterrent; hence the widespread use of fragrant herbs and perfumes. Vermin had become domesticated on the body of man from antiquity onwards, and in the absence of free air, sunlight, and water were able to wax strong and multiply. These creatures, so it was believed, did not require parents and could arise out of nothing, clothing materials, dirt, and vegetation. "Not onely children", said Thomas Phaer (1553), "but also other ages, are anoied with lyce they procede of corrupt humour and are engendred with in the skinne, creeping out a lyve through the pores . . . and many have been eaten of lice to death." He advised many forms of treatment, including quicksilver ointment on a "gyrdyll of woollen for the middle of the pacient", but did also enjoin the use of "a lavatory to washe and scoure the body twise a day".

Since the body louse, which breeds in clothing, may transmit the germ of typhus fever (the former "jail fever"), and the flea may act as a vector of bubonic plague, the relationship of an unwashed body, dirty clothes, and unkempt wigs to epidemics of the Middle Ages becomes pretty clear. Vermin were not a prerogative of the populace. Samuel Pepys fraquently refers to those he found in his clothing and bed, and his wife combing her hair found on one occasion twenty "both great and small".

In 1752, Zacharias Plattner, a German physician, wrote a treatise on "Cleanliness". Dirt and sweat retained in underclothing could, he insisted, putrefy into a poisonous miasma (as well as produce vermin) and then be reabsorbed into the skin to produce ill health and fevers. For this reason, and to allow the free passage of insensible perspiration (with its contained corrupted humours), the pores of both the skin and the clothing must, he said, be kept open by thorough and frequent washing. About this period, John Wesley, cleric and physician, taught his flock that "cleanliness is akin to godliness"; a neat apparel was also acceptable to the Lord. By the latter part of the century the forgotten cult of cleanliness was returning among those who could afford it, but the buck and dandy may have played a more important role than either Plattner or Wesley, for elegant, spotless linen displayed at the neck and wrist (and the "slashings" of earlier periods) necessitated frequent baths as well as the services of a laundress.

PHYSIOLOGY, FIBRE, AND CLOTH

The first garments were undoubtedly made from materials most easily to hand: vegetation (bark or leaves) or animal skins; but woven materials like wool, linen, cotton, and silk, are themselves of great antiquity. A scientific interest in textile fabrics is by no means new. Francis Bacon suspected that the warmth of cloth is due to its contained air. Robert Hooke, in his "Micrographia" of 1665, visualised the possibility of producing an artificial glutinous substance resembling silk. At the end of the 18th century, Count Rumford came to the conclusion that air was indeed the source of the warmth in clothing. He measured the thermal insulation of pieces of fabric by wrapping them round a metal cylinder heated by hot water and noting the time taken for cooling. After the middle of the 19th century, experiments throwing light upon the

FIG. 6. During the early part of the 19th century the Directory style, based on the dress of classical Greece, became fashionable. Young women went to garden parties draped in muslin and nothing else. The muslin had been dampened so that it would cling more tightly to the body. In this satirical print of 1803, doctors pay homage to Muslin Disease, who has brought them a large amount of work. (From Holländer.)

FIG. 7. The waning moon line of 1901, achieved by corsets and a blanchet. Dr Franz Glénard had already denounced enteroptosis as the consequence of such excessive constriction of the thoracic-abdominal organs, but corsets continued to get tighter.

physiological properties of textile materials and garments were carried out by two German medical men, Pettenkofer and Rubner. The urgent necessity of producing suitable garments for soldiers, particularly under conditions of climatic extreme, gave a great impetus to the science of clothing during the last war. Although the subject-matter is dealt with adequately in specialised textbooks, data are not easily available.

The smallest unit of clothing made of textile materials is the fibre. A variable number of short or staple fibres are twisted together and spun to form a continuous thread or yarn from which the cloth is produced by weaving and other methods. In the microphysics of the yarns and the geometry of the weave lie many of the characteristics of our clothing.

Up to fairly recent times textile fibres were derived entirely from animal or vegetable products. The former are represented by the hair of animals (sheep, the Angora goat, camel, or llama) or the cocoon of the silkworm. Vegetable fibres are obtained from the seeds, fruits, stems, or leaves of a variety of plants. Thus cotton comes from a seed and kapok from the floss of fruit capsules. Flax, hemp, and jute are derived from the bast fibres of stems. Whereas animal fibres are protein in nature, vegetable fibres are composed of carbohydrates such as cellulose. All natural fibres used in clothing are chemically inert to the skin but can be used as food by certain insects. Cellulose fibres burn easily compared with those of wool and silk. This is one of the serious disadvantages of flannelette (a cotton material whose surface is raised to resemble wool) particularly when used for nightdresses.

Of recent years, fibres have been made from naturally found substances or from synthetic organic chemicals. The former, sometimes given the generic name of "rayons", are at present derived from cellulosic materials (viscose and cellulose acetate rayons), from protein *lanital* and *fibrolane* from milk, *vicara* from corn, and *ardil* from peanuts), or from the complex carbohydrates (pectins) of seaweed. Fibres derived from synthetic substances have a varied chemical composition. Thus terylene (*dacron*) is a polyester, the various nylons and polyamides, and *acrilan*, *dynel*, *orlon*, and *verel* are acrylic in nature. Glass is one of the few synthetic inorganic chemicals used in making cloth, and as in the case of asbestos (the only natural mineral fibre of any importance) its use is limited to fireproof clothing. The fibre-forming property of a synthetic polymer is related to its ability to form long chain molecules of high molecular weight, and only when this is over 10,000 do fibres become suitable for textile manufacture.

In general, synthetic fibres are immune to degradation by bacteria and insects. They melt at fairly low temperatures and, under certain conditions, this may be the cause of severe burns when wearing garments made from such fibres. Synthetic fibres are, like natural fibres, inert to the body surface. The skin rashes sometimes ascribed to nylon stockings are most likely due to the dye or the surface finish. Very little water is absorbed into the interior of synthetic fibres. They tend to produce hard-wearing materials which do not shrink with washing. Being thermoplastic in nature, they lend themselves to the production of materials which can be heat-set—a great advantage in clothing. As commonly manufactured, they are, like the "rayon" and silk fibres, extruded as long structureless filaments and hence convertible into the thin, relatively transparent, tight weaves found in underclothes and shirtings. However, if cut into the short staple lengths of natural fibres (and schappe silk), or by an ingenious method of introducing loops into the filaments, synthetic fibres may be spun into yarns which can be knitted or woven into the texturised, airy, relatively opaque materials found nowadays in wool-like nylon or terylene socks, and in materials resembling cotton poplin of which undergarments and shirtings are made. In blends with natural fibres they can be converted into materials retaining many valuable properties of both systems.

TEXTILE LABORATORY METHODS

Textile technologists use a wide variety of laboratory tests on pieces of cloth, and the results of these (as of purely theoretical considerations) are sometimes extrapolated into the physiological properties of the materials worn as garments. The "warmth" of a piece of cloth is a very highly complex matter. In the textile laboratory, thermal insulation is measured by the heat flow through a piece of cloth resting on a horizontal copper plate whose temperature is kept constant. The resulting "tog" values suggest that thickness (but not necessarily the weight of cloth) is an important simple measure of warmth. A piece of brown paper laid flat on the plate may have a much smaller tog value than when corrugated, and two pieces put on together may have more than twice the value of one. The explanation of these findings is that the insulating air layer between materials may sometimes be as important as those within their interstices. The tog plate method measures the insulation of horizontal systems and

is of value in assessing the warmth of blankets or sheets because they are used in this way. It cannot, however, take into consideration the peculiarities of the air layer between a blanket and the human body beneath it.

The thickness of a piece of material is difficult to measure without deforming its surface. It has sometimes been measured under pressures which rarely occur in a garment except during sitting. Clothing contains linings, extra layers, and pockets, and except on the shoulder (and the buttocks and back during sitting and lying down) is worn vertically. The air spaces between garment layers are related to the shape of the body, and to the drape and fit of the garments. Rumford may have been fortunate to have chosen the cylinder method for measuring thermal insulation, for the body has no resemblance to flat plates but is made up of a number of near-cylinders (trunk, limbs, toes, and fingers) and partial spheres such as the head, tips of fingers and toes. It is well known to engineers that it is much more difficult to lag thermally small pipes than large ones. In the case of the fingers, the warmth of a glove more than a quarter of an inch thick diminishes through the heat loss arising from the added surface area. Clothing layers up to four or five inches thick will, on the other hand, progressively increase thermal insulation around the trunk with its large radius.

PHYSIOLOGICAL ASSESSMENT

Because insufficient is yet known of the microphysics of textile geometry, theoretical concepts tend to fail under the realities of clothing as worn. Furthermore, the anatomical design of a garment may produce pathways of resistance even lower than those of the textile interstices themselves; for instance, around the opening of shoes or boots, at the neck, the arms, the front opening of a coat, and around the bottom of a skirt or jacket. Through such low-resistance pathways, the movement of moisture-laden convection currents from the skin is aided by the bellows effect produced by the trunk in breathing, together with a wind-like action arising with movements of the whole body. Most of these factors cannot be imitated by the methods at present available in the textile laboratory.

As the result of a development in Canada and the U.S.A. during the last war, a full-sized copper mannikin was produced whose surface temperature could imitate that of human skin under comfortable conditions, and which allowed design features of clothing to be taken into account. Overall thermal insulation of a garment, or a combination of garments, can be measured on the mannikin as a "clo" value, one clo being approximately the insulation value of an average man's suit. Although expressed in the same physical units as the tog, the clo value of a shaped garment worn by a man is, clearly, something different from the tog value of a flat piece of cloth. However, it will be clear to the reader that even if the "copper man" gives consistent results it cannot take all aspects of clothing or the body within into account. A porous and an impermeable garment may have the same clo value, yet produce very different physiological effects on an exercising man.

FIG. 8. The first mass-produced corsets caused the wasp waist to become fashionable again. This example of a patented fastening is from an advertisement of the time.

FIG. 9. Botticelli's "The Return of Spring". The large stomach used to be thought very beautiful, and symbolised fecundity.

Enough examples have been given of textile tests and of physical models to demonstrate the fact that valid data on clothing physiology can be derived only from human beings wearing garments under the normal conditions of life.

The subjective qualities of clothing can be assessed in two ways. The first consists of a series of carefully worded questions given separately to the subjects during and after each experimental session. Such questions are related to subjective comfort, and since the items under trial are not mentioned, they are relatively free from bias. Thus, for example, men will be asked whether they feel "ordinary, warm, or hot", "dry, sweaty, or very sweaty" at a particular part of the body or the body in general. It can be seen that such questions may apply not only to thermal sensation but also to rubbing or pinching of the skin as from footwear, and so forth. In the second method men will be separately asked at the end of the whole experiment: "which of the garments did you prefer for general wear, or for wind, rain, snow, and so forth, and why?" Men have opportunity to discuss such matters and their opinions may be modified by others. Such a preference questionnaire must be viewed with some caution, for men (or women) may be prepared to give their opinion on a matter relating to clothing of which they have little experience, give contradictory answers to the same question posed in another way, or change their views for no obvious reason at all. Psychological considerations play a part in the physiological assessment of clothing. Thus soldiers are often biased by the appearance of a garment—whether it is smart, soldierly, or of appeal to the other sex, or whether the appearance or "feel" of the material is to their liking—rather than its more important functional qualities. It is for such reasons that subjective assessments (particularly questionnaires relating to preferences) do not always agree with the objective results.

Fashion is the predominating factor in ordinary life, and physiological function is of much less importance. However, for the soldier or explorer, who cannot often change his garments or always sleep in a bed, suitable clothing, especially for climatic extremes, may be of paramount importance. It is for this reason that research on clothing physiology has been far more active on men and in the military field.

A simple investigation of the clothing worn on a cold or hot day shows the marked differences between individuals in their idea of comfort. For this reason the most elaborate measurements taken from one subject only may be misleading. Physiological differences between garments of varying design or material may be more meaningful than absolute values derived from one only. For this reason clothing studies are, for preference, of a comparative nature; for example, the new *versus* the old, the latter acting as a control. It is thus of more value to compare the physiological effect of, say, nylon with woollen socks than to draw conclusions from the former alone. People are sometimes biased towards or against a new material or a novel design. Since the properties of a garment layer, for instance underclothes, may be affected by the overgarments, all clothing worn at the same time must be regarded as one inseparable unit. Thus, in comparing nylon with wool underwear, the subjects would be fully dressed and all garments identical except the items under test.

To minimise a number of the above variables, a comparative study (for instance, on two or more types of underclothes, socks, hats, outer clothing, and so forth) is made on a group of people—usually soldiers—using as experimental design some form of statistical randomised block such as a Latin Square. Variance or co-variance analysis minimises differences between individuals as also the effects of the time factor (physiological acclimatisation, psychological "learning"). Mean differences can be tested for statistical significance by conventional methods. In the case of subjective measurement some form of non-parametric test, such as the Chi square, is more suitable.

In general, experiments are first carried out in a climatic chamber. Here the air temperature, movement, and humidity, and wall radiant temperature can be controlled. Winds, streamline or turbulent, can be simulated, but the former do not often exist in nature. Although of great value to the physiologist, a climatic chamber has its limitations. It cannot throw light on the effect of sunlight, diurnal temperature change, flora or fauna, sand, rain, snow, and so forth, on either the man or his clothing. Experiments carried out in a hot chamber (with air temperature from 90°F to 120°F and at all humidities) suggest that, because a man sweats less in the nude and hence requires less to drink, clothing is contra-indicated in the tropics. However, trials under real desert conditions demonstrate forcibly that not only is the opposite true, but there are matters of even greater physiological importance than the state of activity of the sweat glands.

The next phase of physiological testing is carried out in the field under appropriate weather or climate conditions. In both the physiological laboratory and during field experiments, the ordinary activities of life (sleeping, sitting, working, and so forth) can, if necessary, be simulated.

Measurements of body temperature are an important aspect of clothing-studies. Skin temperature is measured at various points of functional importance (from which the mean skin temperature can be derived) and internal temperature taken in the mouth or the rectum. Temperature measurements are taken conveniently by thermocouples incorporated on a light-weight harness worn under the clothing. Where data on "sorption" heat have been of interest (heat liberated when water is absorbed chemically into a fibre), temperature and humidity gradients have been also recorded between clothing layers. Under controlled laboratory conditions the insensible perspiration or sweat loss is measured by weighing the individual in the nude state before and after an experiment. The pulse rate and sweat loss give a good measure of body strain arising from the heat of an environment or from that produced internally by muscular work. The change in weight of garments (underclothes, overgarments, footwear, and so forth) may throw valuable light on their "hydrokinetic" properties. Heavy or tight clothing, by impeding movement, will increase the body energy-expenditure for a given amount of mechanical work. This can be assessed by conventional physiological methods.

GEOPHYSICS AND SPACE RESEARCH

By ANGELA CROOME

Who Discovered Antarctica?

Fresh evidence published by the Soviet appears to prove that the first sight of the Antarctic continent can be claimed by a Russian scientific expedition. The evidence concerns the Bellingshausen cruise in Antarctic waters in 1820, and photostat copies of documents relating to this cruise were produced at a recent meeting of the Soviet Antarctic Committee. Due to a strange twist of fate, Lieut Edward Bransfield of the Royal Navy (following up a report by a wide-awake sealing captain, William Smith, and sailing under charter in Smith's brig, the *Williams*) observed the continent and recognised it for what it was within two days of Bellinghausen's sighting.

The Soviet Union has not made any attempt, as yet, to lay specific claims to Antarctic territory as a result of these disclosures; such a move is, in any event, precluded for twenty-five years by the recent Washington Treaty on the Antarctic to which the Soviet Union is a signatory.

It has long been known from the published Bellinghausen papers that the Russian captain—following an exploratory policy derived from that of Capt. Cook, of whom he was an ardent admirer, and, using British navigational instruments, obtained with the help of the Royal Society—saw something that might have been mainland two days before Bransfield did. The curious thing is that the Russians have not previously published the Bellingshausen papers in full. The expedition was a fine achievement and, up to the time of the IGY, the only Russian exploration south. Standard accounts of the discovery of Antarctica are based on a heavily edited version of Bellinghausen's papers, published in 1831 and translated early into English. If the Soviet Antarctic Committee is to make good this omission, students of polar affairs will then have an opportunity to consider the material near its source and finally get the record straight. It may even spur the Admiralty to a further search in their archives for the log of Bransfield's voyage which was deposited at the Admiralty on his return and has since been lost. The actual date of the British sighting of the continent, January 30, 1820, is derived from a published account by another officer of the party and from Bransfield's charts (which have been better looked after than his log).

It is an intriguing and ironical story, this matter of who first discovered the Antarctic mainland and recognised it as such. From Columbus to Cook, exploratory effort south had increasingly demonstrated that there was no great continent over the southern cap of the world. This contradicted the extravagant hopes of late medieval geographers who, on no evidence whatever, predicted that there lay a vast inhabited "spice-land" of untold wealth and glamour. They pronounced it of a size to fill much of the South Atlantic and Pacific, with isthmuses connecting it to Africa and India so that the Indian Ocean would have been reduced to the status of a "tideless pond" on the Mediterranean pattern. Cook, by probing past the Antarctic Circle right round the compass card, finally proved that this was not so, though it was likely that there was some continental structure close in to the South Pole. If land there was, it would not be warm nor rich nor attractive, he reported, quite the contrary.

Cook's farthest probe south (71° 10′) would have set his ships fair and square on the continental icecap if he had penetrated so far in almost any other sector; he was in fact deep into the mouth of the Weddell Sea. As it was, he only saw huge table-like icebergs and deduced the rest. The actual discovery of the continent had to wait very nearly another fifty years.

Then two independent expeditions sighted it in widely separated areas within two days of each other. The further irony is that the Russian expedition has never got much credit for its sighting since the best-known account of the voyage leaves the impression that Bellingshausen did not appreciate what it was he had seen. The published report speaks of a "mound-covered icefield stretching to the south"—not a word about a continent. Bransfield's party believed in a mainland, expected a mainland, and saw the mainland, though in fact it was only a spur of the Graham Land Peninsula jutting hundreds of miles out from the main mass.

The new evidence seeks primarily to establish that the Russian expedition understood the importance of its observation on January 28 of what is now known as the Princess Martha Coast on the eastward lip of the Weddell Sea. It draws on a letter written by Bellingshausen's lieutenant, Lazarev, captain of the expedition's second ship, *Mirny*, to a naval friend at home. In this, it is reported, he writes of an independent observation of "an ice-clad shore" from the *Mirny*'s mast-head, and that "very high solid ice extended as far as the eye

The launching of the second and successful 400-ft.-high balloon in the series of three supervised by Chicago University and directed to observing unusual atomic events when cosmic rays impact photographic emulsion stacks above the atmosphere. This flight, made from the Caribbean with the co-operation of the U.S. Navy, recorded four hours of such impacts above twenty miles high. Picture shows the giant balloon partially filled with helium. By adjusting the ship's speed to compensate for wind velocity, the balloon stands straight up, as here. Much of it is still going through the rollers along the deck.

could see". Further that "from that point onwards we sailed eastwards, attempting to turn west repeatedly, but ran into the ice-covered mainland each time, short of 70° S". Bellingshausen reported from Sydney to the Russian Minister of the Navy, and this document has now been released also. In the report, the expedition leader used the word "mainland" in discussing a further probe south, in February 1820, which suggests he understood the significance of earlier observation.

TABLE OF MAN-MADE OBJECTS CURRENTLY IN ORBIT

NAME		INITIAL ORBIT									RADIO	
General	*Astronomical*	*Up*	*Lifetime*	*Shape and size*	*Period*	*Distance away*	*Angle to Equator*	*Weight*	*Instrumentation*	*Scientific Value*	*Characteristics*	*Lifetime*
Explorer I (rocket and instrumented nose-cone)	1958 α	Jan. 31, 1958	4·8 years	Cone-nosed tube, 80 × 6 in.	114·8 mins	219 to 1587 miles	33·2°	30·8 lb. payload 10 lb.	2 Geiger counters, micro-meteorite detector	Discovery of Van Allen radiation	108 Mc/s (high power) 108·03 Mc/s (low power)	2¼ weeks 3 months
Vanguard I (instrumented sphere)	1958 β2	Mar. 17, 1958	100 years	Sphere, 6·4 in. diam.	134·2 mins	404 to 2466 miles	34·3°	3¼ lb.	Inside and outside thermometer	Geodetic studies	108 Mc/s (high power) 108·03 Mc/s (low power)	2 weeks Indefinitely, unless
Vanguard I (rocket)	1958 β1	Mar. 17, 1958	100 years	Cylinder, 48 × 20 in.	138·5 mins	404 to 2466 miles	34·3°	50 lb.	—	—	—	—
Lunik I (rocket and instrumented nose-cone)	Artificial Planet 1	Jan. 2, 1959	Indefinite	Cone-nosed tube?	450 days (round Sun)	91,000,000 (Jan. 14) to 122,000,000 miles (Sept.) —from Sun	Passed within 3700 miles of Moon	3245 lb. payload 797 lb.	9 experiments to follow up *Sputnik III* observations and relate them to conditions in space		19·993 Mc/s 19·995–19·997 Mc/s 183·6 Mc/s	? 62 hours
Vanguard II (instrumented sphere)	1959 α1	Feb. 17, 1959	50 years	Sphere, 20 in. diam.	126 mins	335 to 2300 miles	33°	21 lb.	Photo-cell recording equatorial cloud-cover	Weather forecasting	108 Mc/s (tracking) 108·03 Mc/s (telemetry of tape-recorded data)	4 weeks (ceased
Vanguard II (rocket)	1959 α2	Feb. 17, 1959	50 years	Tube, 48 × 20 in.	130 mins	335 to 2050 miles	33°	50 lb.	Painted to facilitate visual tracking	—	—	—
Pioneer IV (instrumented nose-cone)	Artificial Planet 2	Mar. 3, 1959	Indefinite	Cone, 20 × 9 in.	392 days (round Sun)	91,700,000 (Mar. 17) to 102,400,000 miles (Oct. 1) —from Sun	Passed within 3700 miles of Moon	13·4 lb.	2 Geiger counters differently scaled; photo-cell; de-spin device	Van Allen radiation's penetrability, and extension into space	960·05 Mc/s (tracking and telemetry)	82·4 hours. Ceased 407,000 miles
Explorer VI (instrumented capsule)	1959 δ1	Aug. 7, 1959	? 2 years	Spheroid + 4 vanes, 26 in. diam.	12·75 hours	136 to 22,900 miles	47°	142 lb.	High-, medium-, low-energy radiation experiments and magnetic field measurements; "Whistler" radio experiment; cloud-cover scanner; micro-meteorite microphones	Detailed cross-section of radiation surrounding the Earth	UHF transmitter digitalised memory 108·06 Mc/s low-power telemetry, 108·09 Mc/s low-power telemetry LF transponder receiver, HF receiver	Stopped prematurely
Explorer VI (rocket)	1959 δ2	Aug. 7, 1959	? 2 years	Cylinder, 48 × 20 in.	?	?	?	50 lb.	—	—	—	—
Discoverer V (capsule)	1959 ε2	Aug. 13, 1959	15 months	Cone frustum, 36 × 24 in.	94·3 mins	117 to 399 miles	80°	300 lb.	—	Attempt at recovery from space (failed)	—	—
Vanguard III	1959 η	Sept. 18, 1959	150 years	8-ft. sphere-ended cylinder with nose. 20-in. sphere, 26-in. nose	130 mins	276 to 2023 miles	33·3°	100 lb. payload 50 lb.	Magnetic measurements. Solar x-rays produced by solar flares; various temperature and micro-meteorite measurements	Solar flare observations	108·00 Mc/s transmitting continuously 108·03 Mc/s telemetry on command	3 months
Explorer VII (instrumented capsule)	1959 ε1	Oct. 13, 1959	20 years	Double cone, 30 × 30 in.	101·5 mins	300 to 588 miles	50·3°	91 lb.	Van Allen and cosmic radiation measurements; Earth's heat-balance; micro-meteorites; x-rays	Earth's heat-balance	108·03 Mc/s telemetry on command 20 Mc/s	1 year by batt
Explorer VII (rocket)	1959 ε2	Oct. 13, 1959	10 years	Cylinder, 42 × 6 in.	101·3 mins	298 to 586 miles	50·3°	—	—	—	—	—
Pioneer V (artificial planet)	1960 α	Mar. 11, 1960	100,000 years	Spheroid 26 in. diam. + 4 vanes	311·6 days (round Sun)	74,900,000 to 92,300,000 miles from Sun	3·35° to ecliptic	94·8 lb. payload 40 lb.	4 radiation detectors; micro-meteorite detector; aspect indicator	First measurements of magnetic field and particle flux in interplanetary space	378 Mc/s with 1 low-power (5 W) and 1 high-power (150 W) transmitters	3¼ months on low transmitter, a Batteries could sustain high-po transmission contact at 22 mil
Tiros I	1960 β2	Apr. 1, 1960	20 years	Cylinder, 19 × 42 in. diam.	99·19 mins	428 to 466 miles	48·3°	270 lb.	2 cameras of complementary function to photograph cloud-cover	Test of cloud-cover photography and relay system for meteorological purposes	235 Mc/s (TV transmission) 108 Mc/s and 108·03 Mc/s for tracking	3 months 3+ months
Tiros I (rocket)	1960 β1	Apr. 1, 1960	5 years	Cylinder, 48 × 20 in.	99·15 mins	428 to 466 miles	48·3°	50 lb.	—	—	—	—
Transit IB	1960 γ2	Apr. 13, 1960	1 year	Sphere, 36 in. diam.	96 mins	233 to 479 miles	51·3°	265 lb.	Ultra-stable oscillators; infra-red rotation scanner	First trial of all-weather high-precision navigational system	54 Mc/s 162 Mc/s 216 Mc/s 324 Mc/s	1–3 months
Transit IB (rocket)	1960 γ1	Apr. 13, 1960	1 year	Cylinder, 178 × 55 in.	96 mins	233 to 479 miles	51·3°	1000 lb.	—	—	—	—
Transit IB (nose-cone)	1960 γ3	Apr. 13, 1960	4 months	Cone	96 mins	220 to 460 miles	51·3°	—	—	—	—	—
Sputnik IV	1960 ε1	May 15, 1960	2 years*	? Cone	91 mins	188 to 229 miles	64·9°	10,008 lb.	Environmental system complete with "dummy man" for manned space flight	Test of system for placing man in orbit	19·995 Mc/s (telemetry and "telephone"—using taped voice for vehicle to ground)	1½ months
Sputnik IV (rocket)	1960 ε2	May 15, 1960	3 months	? Cylinder	91 mins	195 to 200 miles	64·9°	?	—	—	—	—
Sputnik IV (cabin)	1960 ε3	May 19, 1960	4 years*	?	94·25 mins	191 to 429 miles	64·9°	5512 lb.	See 1960 ε1	See 1960 ε1	See 1960 ε1	See 1960 ε1
Sputnik IV (6 pieces of rocket casing)	1960 ε4 to 1960 ε9	May 19, 1960	? *	—	94·3 mins (average)	191 to 429 miles	64·9°	—	—	—	—	—
Midas II	1960 ζ1	May 24, 1960	2 years	Cylinder, 22 × 5 ft.	94·3 mins	292 to 322 miles	33°	5000 lb.	Infra-red scanner (details not released)	Test of missile launching detection system	Not released	2 days
Midas II (nose-cap)	1960 ζ2	May 24, 1960	?	—	94·3 mins	292 to 322 miles	33°	—	—	—	—	—
Transit IIA (U.S.)†	1960 η1	June 22, 1960	50 years	Sphere, 36 in. diam.	101·7 mins	389 to 665 miles	66·7°	223 lb.	2 ultra stable oscillators; infra-red rotation scanner	Detection of "galactic noise" type of radio waves (ULF)	54 Mc/s 162 Mc/s 216 Mc/s 324 Mc/s	1 year
NRL Satellite	1960 η2	June 22, 1960	50 years	Sphere, 20 in. diam.	101·6 mins	382 to 657 miles	66·8°	42 lb.	Very long radio wave-detectors	Measurement and solar radiation	108 Mc/s (telemetry and tracking)	1 year
Discoverer XIII (Preliminary)	1960 ι1	Aug. 11, 1960	1–2 months	Cylinder 19 ft. long, 5 ft. diam.	94 mins	160 to 434 miles	82·9°	1400 lb.	Classified	Carried recoverable capsule	Classified	—
Echo I (Preliminary)	1960 ι1	Aug. 12, 1960	Some years	Sphere, 100 ft. diam.	118 mins	945 to 1049 miles	47·2°	167 lb.	Two transmitters for tracking	Radio reflector, benchmark for geodetic measurement	107·94 Mc/s	Indefinite

* On May 19 the instrumented section of *Sputnik IV* was separated from the remainder of the vehicle. The "cabin" and no less than six pieces of the satellite casing were then flung into orbit, accounting for 1960 ε3 to 9. Owing to the misalignment of the retro-rocket at separation, these objects went into higher orbits and consequently have a longer expectation of life than the parent vehicle (also still in orbit).

† Two satellites were placed in orbit at one rocket-launching.

NEW SCIENTIFIC INSTRUMENTS

ARTHUR GARRATT

Cadmium sulphide photocell radiation monitor for measuring the gamma-ray absorption of tissues and organs.

The study of surfaces has produced many ingenious instruments. A new technique of "seeing" the invisible surface which controls the performance and durability of paint was announced at the American Chemical Society's third Delaware Valley Regional Meeting. The method of studying surfaces of the order of 0·2 μin. thick consists of brushing potassium bromide powder on to the surface, removing it and pressing it into a disc for infra-red analysis. It allows investigations of the upper 25 to 50 Å. Early results with paints containing silicone oil have shown that the oil concentrates at the film surface while the slip agent in polyethylene film appears at the surface.

Another new technique, electric particle testing of ceramics, enables surface cracks to be detected and located quickly and cheaply. Based on simple electrostatic principles, cracks are shown by spraying the object with "Statiflux", a variety of calcium carbonate with a strong positive charge. If the non-conducting object is backed by a metal, free electrons in the backing move towards the interface due to the Statiflux attracting them through the ceramic. If the ceramic is cracked, the pull is greater and the powder accumulates at this point. If the ceramic is not metal-backed, it is treated with a wetting agent. After wiping, this remains in the cracks and when the powder is applied ionic separation occurs in the wetting agent giving the same effect as the electron migration in a metal backing. In this case, the Statiflux can be applied on either side of the ceramic.

A new thickness gauge, the **Accuratest**, measures the thickness of non-conducting coatings on non-ferrous metals. A spring-loaded probe contacts the surface and the coating affects the inductance in the probe. Measurements, accurate to $\pm 10\%$, can be made over three ranges, 0–0·0025 in., 0–0·005 in., and 0–0·01 in. The instrument is calibrated on a non-coated specimen of the same contour and requires a measuring area of at least $\frac{1}{4}$ in.

Many quite common gases are soluble in solid metals and can have far-reaching effects on the metal's behaviour. A new apparatus has been developed which rapidly measures the quantity of hydrogen dissolved in steels. An inert gas, argon, is passed over the sample of steel heated in a furnace. The argon acts as a carrier and sweeps the hydrogen along to a sensitive cell from which the result is plotted directly on an electrical graph recorder in the form of a peak. As little as 1 part in a million of hydrogen can be detected and measured. This hydrogen measuring apparatus requires only 15 minutes to make an analysis compared with 2 hours using conventional methods.

Also in the field of metallurgy, a new **Corrosion-Resistant Process** for ferrous metals is now available in Britain. Well established in the United States, it consists of coating the object with Bostik "Endurion" after base phosphate treatment. It is claimed that parts will remain serviceable sixteen times as long as parts treated with dry phosphate and oil. It has excellent bonding qualities for use as a paint base without affecting gloss and gives a finish that neither chips nor peels.

Among the new medical instruments is an application of the **Vibron Electrometer** to measure changes in *p*H value of blood. Dr Yamamoto of the University of Pennsylvania has applied the technique to the study of the electropotential between blood-stream and brain using electrodes only 40 μin. in diameter filled with saline solution. Changes as small as $\pm 0{\cdot}003$ in *p*H value can be measured.

In collaboration with the Cardiac Department of St George's Hospital, London, a **Cardiac Stimulator,** designed to provide controlled electric shock pulses for the treatment of ventricular standstill has been developed. It contains important new features, such as audible warning of heart standstill and internal batteries for use when mains are not available. In case of mains failure, operation continues automatically on the batteries. The machine works on the principle of transmitting a succession of electric impulses through the intact chest wall. These are strong enough to stimulate the ventricles directly but are too small and short to cause fibrillation.

Computer technology continues to progress rapidly. It is announced that **Leo III,** an advanced all-transistor computer, is now in pilot stage. The first production model should be complete by the middle of 1961. It contains a very large directly accessible magnetic-core storage with automatic checking and time-sharing facilities to enable two or more programmes to operate concurrently. Speed of operation has been improved by using more high-speed tapes instead of punched cards. Ninety thousand characters per second can be fed into or extracted from the computer. It has been designed particularly for office applications but can also be used for scientific and research calculations.

Tests are going on in Atlantic City with a new **Air Traffic Control Computer.** This

provides a complete data processing system capable of processing and printing 1600 flight progress slips per hour and processing 440 aircraft flight plans per hour. Its memory can store a total of 1000 different aircraft flight plans and it can sequence the arrival or monitor the departure of 90 aircraft per hour.

Both analogue and digital computers have developed side by side in the last decade, but there has been little effort to combine the advantages of each into one piece of apparatus. It is thus a significant piece of news that the **Radic System** does just this. It claims to be the first of its kind in the world specially developed to integrate the stability, convenient input/output equipment and extensive storage facilities of the digital machine with the speed of operation, ease of programming, and low cost of the analogue computer. It is particularly applicable to the analysis of automatic process control equipment but it will also be valuable to the economist and statistician. Its accuracy, 1 part in 100,000, is better than purely analogue machines. Basically it consists of an assembly of direct-current drift-corrected amplifiers, electronic multipliers and diode-network function generators all operating on a relatively fast time-scale. It has a magnetic-tape storage system which extends its field to complex types of input data beyond the capabilities of conventional analogue machines. The magnetic tape is sprocket-driven so that the time-scale and data recorded may be quantised.

There has been further progress in machine-tool control. The **Autonomic Co-ordinate Drilling Machine** operates completely from tape. This controls the machine in respect of positional or co-ordinate information, depth information, and tool information. It is accurate in positioning to $\frac{1}{2}$ thou., the position is determined independently of lead screws, and so forth, by optical scales with 100 lines/in. Friction is reduced by making the table run on a film of oil under pressure from an external pump.

The use of Moiré fringes for machine tool control has been extended at the National Engineering Laboratory, in collaboration with the National Physical Laboratory, by the production of a gear-hobbing machine which automatically corrects for its own errors. The NPL has also use Moiré techniques for measuring twist in a rotating shaft. Two radial gratings, one at each end of the test length, form fringes with fixed reference gratings and the phase difference between them depends on the torsional strain in the test length. Alternatively the signals may be developed by tracks on magnetic oxide coated discs. In addition to the improved accuracy due to absence of drift, the system eliminates slip-rings.

Two new Piezoelectric Compounds have been discovered. These are zinc oxide and cadmium sulphide. The effect in zinc oxide had previously been masked by excess conductivity, now neutralised by doping with lithium. This acts as an acceptor for excess electrons and raises the resistivity from 10^3 to 10^{12} ohm-cm. at room temperature. The degree of piezoelectricity is then about four times as great as quartz. The cadmium sulphide crystals were vapour-grown and exhibited a degree of piezoelectricity about twice that of quartz.

From France comes the **LIP Electric Comparator**, an instrument weighing only 6 oz. and smaller than the palm of a hand. Coupled directly to the mains, it provides mechanical amplification, visual control by coloured signals and a measuring accuracy of $\pm 0{\cdot}0001$ in. with high sensitivity.

Another example of miniaturisation is a new **Cadmium Sulphide Photocell Radiation Monitor.** This is so small, 14 mm. long and 1·7 mm. in diameter, that it can be swallowed or inserted into a patient to measure the gamma-ray absorption of tissue and organs. (See photograph.)

Electrothermal Temperature Probes only a few hundredths of an inch in diameter enable precise temperature measurement without disturbance. These probes contain thermistors, are highly stable and exhibit no hysteresis. A typical probe covers the range from $-30°C$ to $+220°C$ and has a time delay of the order of 15 seconds.

A new way of using a symmetrical transistor as a chopper has been developed. It is claimed that setting-up is reduced to a minimum and performance can be guaranteed from standard transistors. Results over a temperature range of $-40°C$ to $+100°C$ are better than 1 μV/°C.

A miniaturised, portable **Potentiometer Recorder** is now available. It provides a chart width of 4 in. and the clockwork motor operating it will run continuously for eight days. It weighs less than 10 lb. and covers the ranges of 0 to 5 mV and 0 to 1 V.

A **Radio Telemetering System** has been built capable of transmitting information from rapidly moving parts, such as the piston in an internal combustion engine. It is fully transistorised and operates on a carrier frequency of 2 Mc/s.

Finally it is gratifying to report that the second edition of **British Instruments** has been published. It demonstrates the increase in the number of new instruments developed in the last year by being 25% larger than the first edition. It contains the most comprehensive list of British scientific instrument manufacturers and their products yet compiled.

MANUFACTURERS

Method of Studying Surfaces. Dupont Co., Marshall Laboratory, Philadelphia, Pennsylvania, U.S.A.

Electric Particle Testing of Ceramics. Solus-Schall Ltd, Honeypot Lane, Stanmore, Middlesex.

Accuratest Thickness Gauge. Nash and Thompson Ltd, Hook Rise, Tolworth, Surrey.

Hydrogen Measuring Apparatus. British Welding Research Association, Abington Hall, Cambridge.

Corrosion-Resisting Process. B.B. Chemical Co. Ltd, Leicester.

Vibron Electrometer. Electronic Instruments Ltd, Richmond, Surrey.

Cardiac Stimulator. Firth Cleveland Instruments Ltd, Pontypridd, Glam.

Leo III. J. Lyons & Co. Ltd, London.

Air Traffic Control Computer. General Precision Systems Ltd, Aylesbury, Bucks. (British Representatives.)

Radic System. Redifon Ltd, Crawley, Sussex.

Autonomic Co-ordinate Drilling Machine. Staveley Research Dept, Clapham, Bedford.

Moiré Fringes for Machine Tool Control. National Engineering Laboratory, East Kilbride, Scotland.

Measuring Twist in a Rotating Shaft. National Physical Laboratory, Teddington, Middlesex.

Piezoelectric Compounds. Bell Telephone Laboratories, 463 West Street, New York 14, N.Y., U.S.A.

LIP Electric Comparator. Microtron Ltd, 287 Finchley Road, London, N.W.3. (British Representative.)

Cadmium Sulphide Photocell Radiation Monitor. Associated Electrical Industries Ltd, 155 Charing Cross Road, London, W.C.2.

Electrothermal Temperature Probes. Electrothermal Engineering Ltd, 270 Neville Road, London, E.7.

Transistor Chopper. Smiths Aviation Division, Livingstone College, Leyton, E.10.

Potentiometer Recorder. Mervyn Instruments, Woking, Surrey.

Radio Telemetering System. British International Combustion Engine Research Association, Trading Estate, Slough, Bucks.

British Instruments. United Science Press, London.

THE BOOKSHELF

Co-operation in the Field of Scientific and Technical Research

(OEEC, Paris, March 1960)

This report by Mr Dana Wilgress, former head of the Canadian Delegation to the OEEC, is a study which this distinguished Canadian public servant has made for the Secretary-General of the OEEC, and is of quite exceptional significance.

Mr Wilgress's terms of reference in the field of scientific policy were appropriately wide; they included surveying the scientific resources and programmes of member-countries, making high authorities aware of the importance of scientific research, and proposing measures for common action. He does not mince his words. Though recognising the difficult task which European countries face in preserving their unique cultures while making the necessary adjustments to modern needs, he quite bluntly states in effect that we in Western Europe have not yet accepted the full implications of the scientific revolution.

Mr Wilgress rightly emphasises that if Europe is to progress economically, her scientific effort must be greater and better co-ordinated. It is therefore regrettable that outside of CERN, "there is comparatively little co-operation between governments in relation to science and technology". While Europe was the home of the great scientific discoveries of the past, there is today a real danger of her standing still while the U.S.A. and the U.S.S.R. forge ahead. Britain, thanks to the scientific stimulus of the war, is in part, but only in part, excluded from this stricture. Among contributory factors to which Mr Wilgress directs his attention is the over-liberal character of university education, social prejudice against manual labour, affecting applied science, inadequate arrangements—rather better in Britain—for utilising inventions, the dominance of cost accountants, the innate conservatism of medium and small-sized businesses and the universal shortage of scientific and technical manpower, which seems to have been to some extent overcome in Germany alone.

The issue of academic freedom is not shirked. Universities should enjoy freedom, but they also have a responsibility towards their parent country. Provocative, too, is the view that European students, who compared with their American counterparts were too restricted at school, do not have a sufficiently rigid time-table at university. Implicitly these, and many other matters cannot be righted unless, to quote the Report's central recommendation, "each country (draws) up a national science policy", involving the allocation of greater proportions of the nation's resources to scientific and especially applied scientific research. Other subsidiary points and suggestions are: much more use of contract research by industry, the influence of personal contact in spreading science-mindedness, more scope for research-leaders. Finally, there is the need for streamlining the OEEC's Scientific Committees' policy structure, for that body alone is in the position to develop the necessary co-operation in the field of scientific and technical research which is necessary for the area's economic progress in which, for better or for worse, that of our own country is so deeply involved.

Man Explores the Sea

By James Dugan (*London, Pelican Books Ltd, 1960, 416 pp., 6s.*)

James Dugan's book would have been more aptly named "Man explores under the Sea" because the present title seems to do scant justice to the wealth of fascinating and unusual material to be found between the covers. The author is a painstaking collector of detail, travelling all over the world and making meticulous notes of all that he sees and hears. As a result, he presents a wealth of authentic and largely original information as he traces the pattern of man's efforts to probe beneath the surface of the sea, from the earliest primitive efforts to the modern nuclear submarine.

His style is fast-flowing and conversational, and he lightly leads the reader through every aspect of underwater adventure; salvage-diving, treasure-hunting, deep-diving records, archaeology, photography, and spear-fishing.

As an "ex-submariner", I was naturally intrigued to read of the vicissitudes of the early inventors of the submarine; Fulton, Simon Lake, and Holland; and of the intrepid "Davids" who blew up their "goliath" targets (and themselves) with bombs lashed to a spar. It is a far cry indeed from them to the mighty U.S.S. *Nautilus* or to the Bathysphere, with whose dive into "the abyss" Dugan so fittingly ends his book.

My only criticism lies in the Chapter "The Wet Saboteur", with whose activities I was so closely connected during the War. His eulogy of the Italian "human torpedo" divers leaves no room for credit to their British counterparts; in describing the combined Anglo-Italian attack on the German-held Italian cruiser *Bolzano* at La Spezia, he ignores the fact that the target was destroyed by a British "human torpedo" crew and that the Italians all failed to reach their objectives. He is incorrect too in describing the successful "midget submarines" as being "pioneered by the Japanese and adopted by the British". The two nations used totally different craft and methods of attack. The *X-craft* which mortally wounded the *Tirpitz* in 1943 were a wholly British development.

These, though, are perhaps personal criticisms, and the general reader will, I am sure, find this book and its copious illustrations at once absorbing and instructive.

W. O. SHELFORD

The Triumph of Surgery

By Jurgen Thorwald (*London, Thames & Hudson, 1960, vii+483 pp., 25s. net*)

We are all familiar with Jurgen Thorwald's book "The Century of the Surgeon" and quite expect the present volume to be as interesting and as dramatic as the former. Readers will not be disappointed for the author has presented us with a book written in the same lucid style and framework as that portrayed in "The Century of the Surgeon". Jurgen Thorwald has the ability to present the reader with a fascinating story of the progress of surgical technique since the year 1881. The early days of cerebral localisation by David Ferrier and the first brain operation for the removal of a tumour by Rickman Godlee are told in a stimulating way.

The professional jealousy of the German and British surgeons over the disease which killed Friedrich III is the best descriptive account that so far has been penned.

The great surgeons of this period, Lister, Macewen, Kocher, Lawson, Tait, Victor Horsley, and the Mayo brothers are all incorporated in this book and the

dramatic events which took place in their clinics, at their operations, and in their social lives which were to revolutionise surgical practice are all recorded. The author seems to be able to make these great personalities live again in these chapters.

This book will make a strong appeal not only to the medical profession as a whole but also to the lay public.

The translators Richard and Clara Wilson are to be congratulated on their excellent English rendering of the German version.

An admirable production. C. WAKELEY

Applied Geography

By L. Dudley Stamp (*Pelican Books Ltd, 1960, 208 pp., 3s. 6d.*)

At every stage of human history geographical factors have played their part. Dr Stamp insists that so far from man having now emancipated himself from their influence, in the world as constituted today they are more important than ever in the past. The growth of population—and of "death control"—make it more than ever vital that land, for whatever purpose, should be used to the best, most economical advantage. This necessitates first-hand survey in the field, followed by the systematic and objective arrangement of the facts. The geographer makes his special contribution by the method of "cartographic analysis"; the study of "distribution"—of population, natural resources, relative soil fertility, and so forth—by means of data on maps.

Dr Stamp shows us the geographer's work applied to typical present-day problems, rural, urban, industrial. In one especially interesting chapter he describes just how the Land Utilisation Survey of Britain, organised by him in 1930 and completed before the outbreak of war in 1939, was carried out. J. F. HORRABIN

The Other Side of the Moon

Issued by the U.S.S.R. Academy of Sciences. Translated from the Russian by J. B. Sykes (*London, Pergamon Press, 1960, 36 pp., 10s. 6d.*)

This book deals with the Russian space-vehicle *Lunik III*, which was launched in October 1959, and transmitted photographs of that part of the Moon which is permanently averted from the Earth. There are four sections: "The Design of the Automatic Interplanetary Station", "The Orbit of the Interplanetary Station", "Photography and Image Transmission", and "The Unseen Side of the Moon". The Foreword is by Academician A. N. Nesmeyanov, President of the U.S.S.R. Academy of Sciences; and the translation has been excellently carried out by J. B. Sykes.

The book has been eagerly awaited, but unfortunately it proves to be a grave anti-climax, and is disappointing in many ways. It includes virtually no new material, and all that it contains was included in an excellent booklet, *Soviet Moon Rockets*, published as a paper-back some months ago at the modest price of 1*s*. This booklet contained, indeed, more illustrations than the present volume. The Pergamon production has less than fifteen full pages of text, so that its price must be regarded as exorbitant; and though the photographs and drawings are well reproduced, they have all been seen before in many publications. In addition, the book is not up to date. Nothing is said of the premature failure of the *Lunik*'s transmitters; there is no mention of the new names of lunar features recently announced by the Russian authorities.

P. MOORE

Science in Secondary Schools

(*Ministry of Education Pamphlet No. 38, H.M.S.O., 1960, 6s. net*)

The Scientist: Laboratory Technicians and Assistants: Choosing Your Career

(*Three "Choice of Careers" Booklets, prepared by the Central Youth Executive. Respectively Nos. 100 at 1s., 94 at 2s. 6d., 1 at 1s. 6d., H.M.S.O., 1960*)

Everybody's doing it. Doing what? Talking about science. And the more they talk, the more confused John Citizen seems to be.

Try this test. Stop the first ten citizens you meet. Ask each one what he understands by the electron. Don't be too discouraged because nine of them shake their heads in ignorance. Just reflect on the millions of words that have been spilled out about the atom since 1945, and wonder, with me, where they have all got to.

So far as I am concerned, popularisation of science—hateful phrase—as I embraced it in the thirties has had it. It meant something then. It means little today.

There's a place for the science news reporter. But there is no place for the populariser of science. There is for the person concerned with the popular presentation of science, and the most important place is in education. The general science teacher is for me the prototype of the new popular presenter of science.

That is why I welcome "Science in Secondary Schools". It makes the case for general science so well, and it is so full of common sense. For example: "The problem of what part science is to play in education is at least twofold. There is the training of the necessary specialists to operate the machinery of a scientific society, and the education of all (including the specialists) to enable them to keep some measure of control over their own destinies. Our future community will not only need more specialists able to maintain the machines of the automatic age, but also more citizens capable of imaginative and creative thinking within the context of science."

There is no space here to go into the detailed statement of the pamphlet, but I must refer to the shameful way in which girls are treated as second-rate citizens so far as science is concerned. This country cannot afford sex discrimination of this kind.

The anonymous group of Her Majesty's Inspectors who have written this Survey are to be congratulated.

"The Scientist" is No. 100 in the series of Careers pamphlets. The illustrations are good, especially the delightful historic one of Rutherford at the Cavendish (Who is he talking to?).

I object to the statement "Nevertheless, there is a certain unity between the natural sciences . . ." Why "a certain"? I recommend the author to read the Education pamphlet mentioned above. And I find the language rather ponderous.

But it is a worth-while pamphlet with a mine of information, as are the other two. All in all, the literature about science is getting better every day. M. GOLDSMITH

The Kew Series
Garden Shrubs and Trees

By S. G. Harrison (*318 pp.*)

British Ferns and Mosses

By Peter Taylor (*London, Eyre & Spottiswoode, 1960, 226 pp., 25s. each*)

Two more volumes of the Kew Series are now available. Volumes one and two, "British Wild Flowers", by Patricia Lewis, and "British Trees and Shrubs", by R. D. Meikle, were released in 1958. The fifth and last volume of the series planned, written, and edited by the botanical staff of the Royal Botanic Gardens, Kew, will be published at a later date. It is "British Seaweeds", also by Patricia Lewis.

R. D. Meikle has provided a key to the Genera for "Garden Shrubs and Trees" which also contains colour illustrations by Ann V. Webster and text illustrations by Ernest Petts. Ann Webster has also done both colour and text illustrations for "British Ferns and Mosses".

The Kew Series is intended to serve as a guide to native and natural plants in

Britain. It is designed for use by students, amateurs, and nature-lovers, and provides scientific information and technical terms as well as plant lore. The illustrations (colour plates and black-and-white drawings) have been specially prepared for the series; detailed keys are provided for identification.

Year Book of Forest Statistics 1959

Food and Agricultural Organisation of the United Nations (*Rome, 1959, London, H.M.S.O., 1960, xl+157 pp., 45 tables, 5 figures, 12s. 6d.*)

This, the thirteenth issue of world-wide statistics respecting production and trade in forest products of all kinds is published in English, French, and Spanish and presents the salient features of the world situation for the year 1958 in great detail. The amount and accuracy of the data presented show an improvement on those of previous year books. Measures are expressed in the metric system and values in U.S. dollars, but tables and conversion factors are furnished in appendices and definitions and a number of notes on various countries are given.

The report is based on information from 124 political units. It deals with fellings of round timber which show a very minute fall-off from the previous year, the value of forest products and of the international trade in them. The importance of the production of fuel wood still remains high but has fallen from 52% to 45% in the last decade. Sawn wood, which includes box boards and sleepers, remains a most important forest product. Other major headings are plywood, pulp, pulp products, other paper, paperboard, and fibreboard, particle board, teak logs, and sawn wood.

A perusal of this valuable record leaves one with a better idea of the continuing importance of the forest as a source of raw materials.

M. L. ANDERSON

Quantitative Genetics

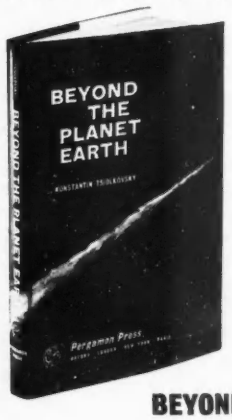
By D. S. Falconer (*Edinburgh and London, Oliver & Boyd, ix+365 pp., 35s.*)

Quantitative genetics is concerned with the inheritance of characters which do not fall into the neat categories and simple ratios of Mendel, but instead show a continuous gradation: as, for instance, human stature, dairy milk yields or drought-resistance in wheat. Indeed, this is the typical pattern of variation encountered in living things. The contrary impression often gained by the student arises from the time-honoured choice by geneticists of "good Mendelian characters" for laboratory study or textbook exposition.

Quantitative variation has been shown to be entirely consistent with a Mendelian mechanism of heredity. The supposition is that a continuously varying character such as stature is controlled, not by a single gene-pair, but by a large number of pairs, each pair behaving according to the Mendelian rule but contributing a small share only to the genetic variation observed. Environmental causes also contribute largely to the total variation.

This picture has been established by methods drawn from mathematical statistics, and for this reason quantitative genetics is often regarded askance as a "difficult" subject. Dr Falconer's book goes a considerable way towards dispelling this attitude. He invokes mathematics only to the extent that his argument demands it, and adopts a simple and common-sense mode of presentation. The problems of natural and artificial selection, the structure of populations, the consequences of inbreeding, and the meaning and estimation of heritability are handled in a way which makes the book an invaluable manual for the student and a welcome reference-work for the specialist.

D. MICHIE



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Tsiolkovsky's

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This brilliantly conceived and historically interesting fantasy, now translated into English for the first time, contains a strictly scientific account of work in preparation for man's penetration into space and the achievement of interplanetary travel. *Beyond the Planet Earth* was partially written in 1896, finally published in 1920. This present translation contains an extensive foreword on Tsiolkovsky's life and work.

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HEINEMANN

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Contents: Serological Introduction—The Rhesus Factor—Haemolytic Disease of the Newborn—Rhesus Antibodies—The Rh Complex—Some Minor Blood Groups and their Notation—The MNS System—The ABO System—P and Lewis—Blood Groups and Disease—Blood Groups and Genetics—Blood Groups and Anthropology—Some Growing Points—Bibliography—Index.

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This valuable little book has been completely revised and brought up to date.

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CHROMATOGRAPHIC AND ELECTROPHORETIC TECHNIQUES

edited by Ivor Smith, Ph.D., F.R.I.C.

When the second edition of *Chromatographic Techniques* was being prepared, it was found that to include all the required new material necessitated considerable enlargement. The editor also received numerous suggestions that a companion work on Electrophoresis would be valuable. As a result *Chromatographic and Zone Electrophoretic Techniques* will be issued in two volumes:

Vol. I Chromatography 624 pages. 183 illustrations. **65s.**

Vol. II Zone Electrophoresis 216 pages. 130 illustrations. **30s.**

(To be published October, 1960)

William Heinemann Medical Books Limited
15/16 Queen Street · Mayfair · London W.1

SCIENCE ON THE SCREEN

Packaged Bricks at the Brickworks

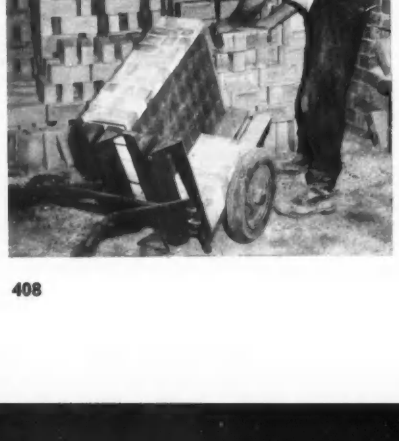
16 mm., colour, sound, 13 minutes. Produced by the Building Research Station of the Department of Scientific and Industrial Research. Script, direction, camera, and editing by J. S. Walker. (*Available on free loan from the Film Officer, Ministry of Works, Abell House, John Islip Street, London, S.W.1, or from the Local Regional Ministry of Works Office.*)

This film, produced by one man, Mr J. S. Walker, is obviously from the same stable as *The New V Brick*. It is made by another section of the Building Research Station, but it bears the earmark of authenticity and scientific objectivity. It is not concerned with the use of bricks but shows their packing and transporting at a brickworks.

This film is aimed chiefly at small and specialised brickworks, but it also hopes to inform the medium-sized production unit. It is at this end of the scale that greater productivity is of vital importance. Therefore it shows hand-operated strapping of bricks and the use of a small hand truck which acts as a jig for two packages of fifty bricks.

The methods of drawing bricks after baking in the kiln are shown, both by normal methods and by the newly designed jig barrow. Apparently these posed immense photographic problems to Mr Walker, whose colour thermometer became completely inaccurate in the heat of the kiln. Because of problems of this sort the laboratory processing of the film were quite complex. Shot-by-shot colour correction was necessary during printing.

Barrow jigs for the loading of packaged bricks have guides through which the steel strapping can be threaded. The straps are then tensioned, joined, and cut by a simple hand-operated tool. The bricks are off-loaded from the jigs at stacking point.



Your reviewer was quite fascinated by this simple process film because it never sidetracked his thoughts, or distracted his attention by so-called "interest shots". It showed the laboratory tests of the strength of the strapping, and the danger of corrosion if stacked in the open.

Scientific and technical films should be made by film units which have a scientific and/or technical background. The units need a real enthusiasm for direct exposition. The more they know about the subject, its detail and intricacies, the more likely they are to produce films like these, which are factual and functional, omitting nothing and avoiding padding.

L. GOULD-MARKS

SCIENCE ON THE STAGE

The Life of Galileo
Bertolt Brecht

It is a platitude that science is now potent, as never before, to change for the better the lives of the majority of mankind. It is a paradox that this situation seems to hold no interest or attraction for the majority of literary or journalistic intellectuals through whom, often enough, science filters to the public. Brecht, in "The Life of Galileo", now running at the Mermaid Theatre, London, earns our respect for his independent and positive assessment of scientific potential.

The action of the play takes us through Galileo's life, from his "invention" of the telescope and his turning it on the skies, through his conflict with the authorities as a result of what he saw there and his recantation of his theories, to his old age. Brecht's style is striking. Each scene is preceded by the lowering of a screen on which a synopsis of the scene is projected. The scenes themselves form a straightforward narrative which sticks remarkably close to historical fact. Yet despite the consequent absence of surprise, one's attention is entirely held by the fascinating arguments between the characters, which are portrayed with a delightfully malicious touch of humour. The only times when one feels historical truth to be somewhat distorted in order to make doctrinal points are when this 17th-century scientist is made to talk like a 20th-century democrat and when the proletariat of the day acclaims Galileo's discoveries in the crowd scene. Even from Brecht's Marxist viewpoint, this is surely "unhistorical". Yet taking these things in a rather more allegorical sense, the essential message—that men may (one day) use science consciously to remake the conditions of their own lives—is a valid and important one.

As regards the production, the main weakness was the screened commentary, in which the wit and irony of the original German had been lost by a bad translation into sometimes laughable silly English verse. I felt that Bernard Miles's interpretation of Galileo, especially in the scenes up to his recantation, did not bring out the elements of sensuality and egoism in his character which are implied in the play, and which makes his recantation seem a more logical development. As it was, Galileo was made to seem too much the principled scientific idealist—admittedly with an admixture of shifty cunning. Among other characters were several noteworthy performances, particularly Michael Griffiths's portrayal of Cardinal Barberini, the witty and intelligent dilettante in science who later becomes Pope, and is persuaded to allow the Inquisition to examine Galileo.

There are those, of course, who say that there is no conflict between Science and Religion. But meanwhile Brecht conducts us round the battlefield—showing us just why the astronomical discoveries should have constituted an intolerable challenge to the Church's authority. However, the play is about more than this particular conflict. It argues for the *relevance* of science, its value as a liberating factor in our material and cultural lives. It was this relevance that caused the conflict—the relevance of science and its methods to our basic beliefs.

Is this relevance generally understood and accepted today? Far from it, to judge by some of the reviews of the play. Apart from those who complained that all this science was so boring, there were those who were unable to fathom why this conflict should arouse any interest at all since they thought that science (referred to by Harold Hobson in the *Sunday Times* as "a mysterious deity"!) had merely replaced one kind of dogma and tyranny by another. What was all the fuss about? The play contains an answer to

this kind of pessimism for it pleads for responsibility and courage on the part of the man of science. Those who fail to see that it is the capitulation of scientists to various established institutions that bring new tyrannies miss a point Brecht tries to make quite explicit.

The play's clarity and unashamed didacticism—it includes some splendid expositions of the scientific method—have an altogether welcome freshness after the arch obscurity of much of the more serious London theatre. The writing and presenting of a play of this quality dealing seriously with the work of one of science's most important figures, is, especially in the contemporary intellectual atmosphere, a thoroughly worth-while innovation.

PAUL WHITEHEAD

LETTERS TO THE EDITOR

"Wet Water"

Sir:

I was interested to read your article on fire fighting. However, one method of improving the present efficiency in the use of water was not mentioned. This is the use of additives to the water in quite low concentrations which make the water cling to surfaces. Research in the U.S. has resulted in spectacular improvements when used on test burnings. I am concerned that over here we seem to be doing nothing to test and use this technique.

Can Mr Hibbitt tell us what the position is over here?

ERNEST PALFREY

Harpenden, Herts.

Sir:

Mr Palfrey refers to the technique of using a wetting agent as an additive to reduce the surface tension of water so that it will spread and be absorbed into the burning material more quickly. This has been tried experimentally on a fairly large scale in the U.S.A., and on a smaller scale in this country.

The addition of a wetting agent certainly increases the efficiency of water in extinguishing small fires in baled textile materials, and in baled hay and straw which are naturally water resistant. It also has some advantage in fighting grass and forest fires where only undergrowth is involved. The use of "wet water" on large fires, however, has no appreciable advantage over plain water in controlling or extinguishing the fire. The reduction in the surface tension of water is of little consequence once the fire has reached a certain stage.

The difference can be illustrated by taking as an example a bale of hay that has spontaneously ignited somewhere near the centre of the bale. In this case, the fire might be extinguished without breaking open the bale by the use of "wet water". If the same bale is broken open and scattered so that the hay burns freely the rate of burning is so rapid that the advantage of adding a wetting agent to the water is insignificant.

The use of wetting agents in portable extinguishers may have advantages, but for large-scale fire-fighting the advantage is so small that it is not worth the trouble of having to provide special apparatus to induce the additive into the water stream.

E. A. HIBBITT

The Cancer Controversy

Sir:

Your annotation on "Smoking: The Cancer Controversy", by Sir Ronald Fisher (Progress of Science, July 1960), discusses the possible causal relation between two observed phenomena, x and y, pointing out that the apparent causal relation may be the result of a third factor, or factors, z, which may be shown to have a causal relation to both x and y; only the elimination of every possible z will leave the statement "factor x causes effect y" beyond dispute.

But there may be another factor, or factors, d, which, while having no numerically significant relation to x, may be shown to have such a relation to y.

During the period 1945–55, total annual consumption of cigarettes in Great Britain rose by 6%; during the same period, the total of certified deaths from lung cancer rose by 100%; while from 1945 to 1955, the total consumption of diesel fuel in Great Britain rose by 160%.

These figures relate to a time when atmospheric contamination in general was steadily diminishing due to the drive for smokeless fuel and the increasing use of electricity for heating, and so forth.

The present exclusive insistence by responsible medical circles on the smoking-lung cancer relation (that is, x causes y) is leading to public apathy and official indifference towards what may well be a factor of prime importance in increasing the mortality-rate from lung cancer and the increase incidence of respiratory disease in general.

There is no doubt that enforcement of existing regulations regarding the management of diesel engines and the provision of adequate filters for all channels discharging diesel fumes would practically eliminate the present grossly offensive and probably noxious effluents.

Revenons! Does increasing excess of d potentiate the latent tendency of x to cause y?

ALLAN CHATELIER

Lewisham, S.E.13.

Science versus Babel

Sir:

It is to be hoped that J. Jackson's article in your June issue will stimulate further discussion of linguistic barriers and their demolition. He must be challenged, however, when he states that auxiliary languages like Esperanto and Interlingua are vitiated by being based on the neo-Latin tongues. They could not be based on radically different families of languages, for phonetic and grammatical reasons. Furthermore, an effective auxiliary must use as its vocabulary those words which have the greatest power of penetration among various speakers. This is a subject upon which a certain amount of preliminary statistical research has been done by Dr J. E. Holmstrom.

Stated in another way, the rise of modern science is linked intimately with the development of those European languages in which the bulk of scientific findings were published until the last few decades. When Oriental scientists study scientific specialities, they necessarily imbibe neo-Latin and neo-Greek terms, either as loan-words or by means of loan-translation. Interlingua (and possibly Esperanto) can act as a bridge-language enabling them to keep in contact with the mainstream of scientific literature without learning four or five Western languages.

Interlingua seems superior to Interglossa (that is, neo-Latin superior to neo-Greek) because most of the Greek roots which appear in modern scientific nomenclature passed a probationary stage in the Latin language, acquiring Latin endings and orthography. The cast of our thought is still neo-Latin, not neo-Greek, in spite of the fact that vast numbers of newly devised Greek words are pouring into all European and many other languages. There seems every reason, historical, syntactical, and phonetic, why we should say for "the previous question" *le previe question* and not *u pre questio*. In the same way, "I gave it to you yesterday" has a much more international appearance as "*Io te lo dava heri*" than as "*Mi date re a tu pre-di*".

RONALD SPATHAKY
(Assistant Editor,
Currero International)

Norwich, Norfolk.

THE PROGRESS OF SCIENCE

(continued from page 373)

LIVING INSECTICIDES

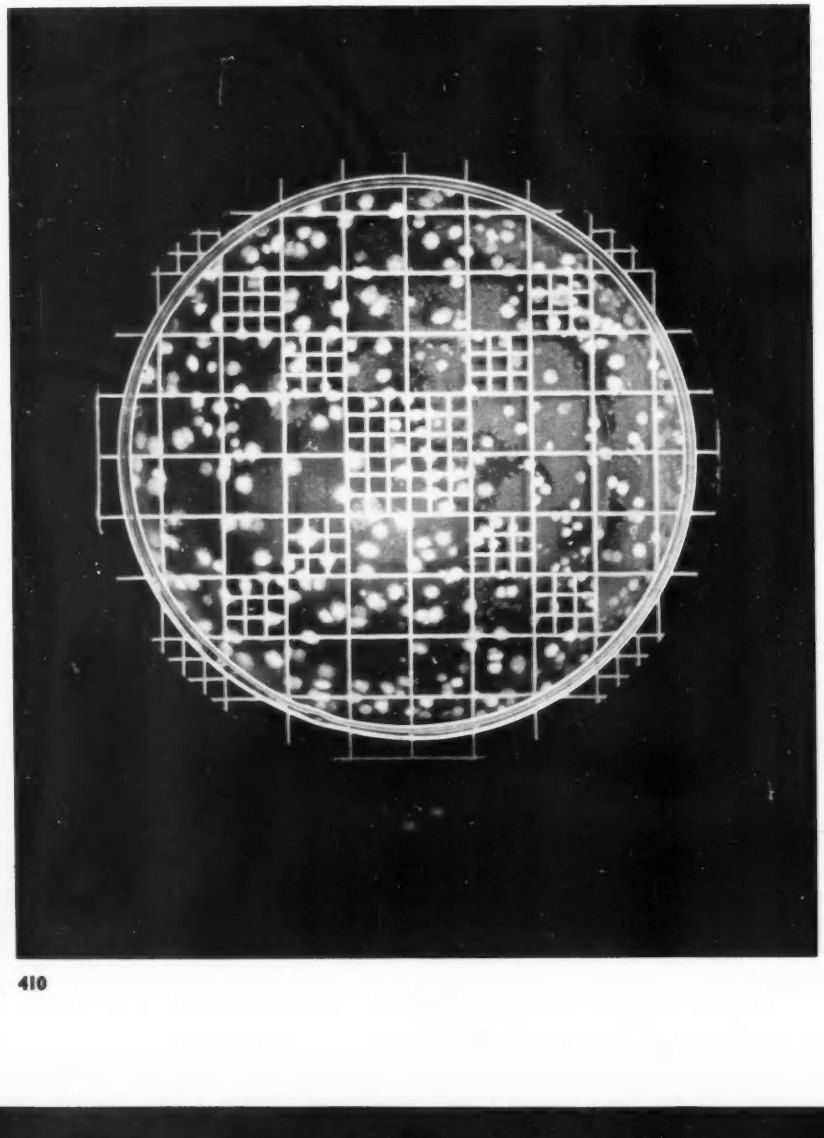
The United States Department of Agriculture has granted permission for the commercial production of an insecticide containing live bacteria for use on a wide range of food and fodder crops.

The possibilities of using disease agents to assist in the control of insect pests have been considered by scientists ever since it was established that infectious organisms did occur in insects. As far back as 1834 Agostino Bassi proved that the Beauveria infection of the silkworm was caused by a microbe, and thirty years later Louis Pasteur went on to establish the germ-theory of disease as applied to animals and man in general.

But, until recently, the only successful attempt commercially to control a serious insect pest by means of an infectious agent has been the application of the bacterial milky disease, *Bacillus popilliae*, against the Japanese beetle in America. As this material is used directly on soil and not on plants it does not require a tolerance clearance.

In 1945 the Division of Agricultural Sciences at the University of California set up the Laboratory of Insect Pathology under its present director Dr Edward A. Steinhaus. It was designed to establish the basic principles of insect pathology, to prepare the field for their practical applications, and to develop a teaching programme to train scientists in this field.

Spores of the *Bacillus thuringiensis* releasing diamond-shaped crystals containing the poison that kills pests. These crystals retain their potency in storage.



In 1950 after a five-year trial period a service was established for the diagnosis of disease in insects. Sick and dead insects were sent to this Laboratory from all over the world and the staff were able to isolate and identify a large number of different organisms attacking insects. In this same year the Laboratory used, for the first time in American pest control, *Bacillus thuringiensis* Berliner. This organism was first isolated in Germany by E. Berliner in 1911 and then again by O. Mattes in 1927. The bacillus was kept alive in a culture some of which was given to Steinhaus in 1942 and kept stored in the Laboratory's refrigerator.

During 1945–50 the staff at the Laboratory had isolated a virus which would kill the alfalfa caterpillar—but it was a rather slow method and it left many dead caterpillars attached to the plants.

Searching for alternatives the scientists tried out *Bacillus thuringiensis* and experiments soon showed that this bacillus killed the caterpillars within forty-eight hours, caused the dead pests to drop to the ground, and could be mass-produced in an artificial media.

It was also shown that the bacillus was non-toxic to other forms of life, did not leave a toxic residue on the treated crop, and that it could be applied and stored in the same way as most chemicals.

So the stage was set for the commercial exploitation of this bacillus and several large commercial undertakings in the United States became interested. The first preparation to receive a permit from the U.S. Department of Agriculture is Thuricide, distributed by the Stauffer Chemical Company of New York. One gram of this microbial pesticide contains 3000 million (3 billion U.S.) live spores of *Bacillus thuringiensis* Berliner. Permission has been given to market forty-nine food and fodder crops treated with this substance. It has been sent for large-scale testing to selected growers in sixteen states, Puerto Rico, Hawaii, and Australia. It is sold as a wettable powder and has proved successful in killing leaf-eating pests on such crops as alfalfa, cotton, lettuce, cabbage, cauliflower, spinach, tomato, and tobacco. Dosages for economic control have been tentatively set at from ½ to 6 lb./acre of the wettable powder concentrate and from 5 to 60 lb./acre of a dust formulation.

This development of a microbial insecticide is claimed to be a major breakthrough in crop pest control. It is thought that beneficial microbes will be used in pest control just as they are being used in chemical and fermentation industries and in the manufacture of dairy and other products.

A NEW STUDY OF INSECTICIDES

The World Health Organisation is beginning to make a thorough systematic evaluation of the entire array of insecticides. High on the list are those that can be used to eradicate the pests and disease-carriers that endanger the well-being of large numbers of people—malaria-bearing mosquitoes, lice, fleas, ticks, and the common house-fly, to name a few. A five-stage programme is being carried out in three British and three U.S. laboratories and one in Tanganyika. Awaited with great interest are the results of tests with a new mosquito-killing fumigant. The potency of this substance was discovered when a bag of it was left overnight in a U.S. research laboratory. All of the laboratory's test insects were found dead the following morning. If insecticides with such killing power can be made available at a price the under-developed countries can afford, we will soon be well on the way towards the control and gradual elimination of malaria, filariasis, and a host of insect-borne parasitic diseases that plague people in the tropics.

PARKINSON AGAIN

The Annual Report of the Hongkong Director of Commerce and Industry contains the following passage: "Owing to the provision of mechanical aid in the statistical branch, it was possible to reduce the number of clerical posts by seven. These were offset by a net increase of eleven posts for staff required to operate the machines." *Newspaper item.*

SPECIAL CONFERENCE TO STUDY SPACE TELECOMMUNICATIONS

The ninety-nation Radio Conference of the International Telecommunications Union, meeting in Geneva, has recommended the convening of an extraordinary conference by the end of 1963 to study the problem of space telecommunication.

This conference will examine progress in the use of telecommunications for space research and will decide on the allocation of frequency bands to be used for research purposes; it will also adopt certain new regulations providing for the identification and control of transmissions from space vehicles.

CLASSIFYING ART SCIENTIFICALLY

Although the importance of systematic classification to analysis and discussion has long been recognised in the scientific world, it is still not generally appreciated in the sphere of art and aesthetics. The nearest approach to a systematic classification of art is today, as it was fifty years ago, the more or less arbitrary division into schools, periods, and movements. This may be adequate for the purposes of an art historian, but it is quite useless to the individual interested in an aesthetic classification. Recently, however, there has been a considerable amount of organised research into both the philosophical and psychological aspects of aesthetics, and as a result of this work—which is to be published under the general title of "Criteria Aesthetica"—an alternative system has been developed.

The new system is based on scientific principles and is more than a mere typology, since it not only facilitates identification and classification but also provides a language for aesthetic philosophy. Traditional generic terms such as primitivism, naturalism, romanticism, and classicism have been excluded because they have been selected haphazardly over the years, lack clarity of meaning; and are used indiscriminately in widely dissimilar contexts. Instead, a completely new and more rational vocabulary has been evolved.

The first differentiation is between the intellectual and the sensible, the second between the conceptual and non-conceptual, the third between form and harmony, and the fourth between the objective and the subjective. Conceptual art can be further subdivided into the representational and presentational.

To illustrate, consider first the difference between the intellectual, on the one hand, and the sensible or perceptible on the other. Art of the former kind differs from that of the latter in that the essence (that is to say, the content and form) cannot be directly apprehended by the physical senses, but only by sustaining intellectual activity of much the same order as that which is necessary to the understanding of, say, a mathematical theory. Perceptible or sensible art, on the other hand, is art in which the form and content are immediately discernible. Thus the average symphony has a direct auditory appeal and therefore falls into the category of perceptible or sensible art, while fugue, which can only be fully appreciated intellectually, is clearly in the opposite category.

The second stage of the system involves a differentiation between conceptual and non-conceptual art. By conceptual art is meant art which seeks to give concrete expression to ideas and images derived from concepts of the external world. Non-conceptual art is concerned to give concrete expression to abstractions which bear no relation whatever to external reality. Put another way, non-conceptual art is concerned with form and harmony to the exclusion of all else.

Form and harmony are not, however, the prerogative of non-conceptual art. They also play an important part in conceptual art. For which reason the third stage of the classification provides for division according to whether form or harmony predominates. Art which has an emphasis on structure and shape is called plastic, while art which lays emphasis on harmony and rhythm is called musical. Naturally, it can be argued that great works of art incorporate both form and harmony in equal parts. This is a legitimate contention, but it is not an unanswerable objection to the dichotomy. Analysis reveals that such works owe their greatness to an amalgam of two entirely distinct arts. Perhaps the best illustration of this is to be found in painting, which requires of the artist competence first as a draughtsman, then as a colourist. As a draughtsman he is practising an essentially plastic art, but as a colourist he is practising an art essentially musical.

Further classification is achieved by distinguishing between objective and subjective treatment in art. Objective treatment consists in the acceptance of formal canons and results in an art of contrivance, since the artist relies on consciously developing techniques and works logically towards a predetermined end. Subjective treatment proceeds on a more personal plane and is mainly governed by the emotional attitude of the artist who works intuitively rather than logically.

The series stemming from the non-conceptual class can be extended no further, but the conceptual series permits of one more subdivision. For in addition to being either objective or subjective, conceptual art can be either presentational or representational. At first sight this may seem an unduly fine distinction, but in point of fact it is quite definite. By representational is meant the direct imitation of external forms which are inherently aesthetic. By presentational is meant the *presentation* of external forms in an original yet aesthetic manner.

One of the most interesting features of the system is that when used to classify a work of art it automatically makes an analysis of the work. Beethoven's Fifth Symphony, for example, is a work of perceptible, non-conceptual art, musical in form and treated subjectively. This is more informative than any conventional classification which at the best would only state that the symphony was an example of early 19th-century German romantic music.

The new system is designed to facilitate the direct comparative study of artistic

and purely aesthetic judgments—an essential preliminary not only to the establishment of aesthetic criteria but also to the formulation of a rational theory of art.

HUNDREDTH ANNIVERSARY OF FIRST INTERNATIONAL SCIENTIFIC CONGRESS

Early in September 1860, over one hundred of the most eminent chemists of the day gathered at Karlsruhe for a three-day meeting which is worth recalling today because it was the first truly international congress in science. As such, it set the pattern for the congresses which have succeeded it in ever increasing numbers during the last hundred years.

The originator of the meeting was August Kekulé, then a thirty-one-year-old professor at Ghent, who had just a few years previously grasped the concept of valency and recognised the quadrivalency of carbon on which structural organic chemistry was to be based. Now, Kekulé had had virtually an international education in chemistry, studying in Giessen, Paris, and London. It is not surprising, therefore, that he should have initiated an international meeting, though it certainly would not have materialised without the help of two other chemists: Karl Weltzien and Adolphe Wurtz. Weltzien was a German-trained medical man of Russian origin and the professor of chemistry at the Technische Hochschule at Karlsruhe. Wurtz was Dumas' successor in Paris, famed for his synthesis of hydrocarbons and as the discoverer of amines.

A preliminary meeting of these three in Paris in March 1860 resulted in a notice circulated in July to their colleagues throughout Europe and signed by forty-five chemists. This proposed the subject of the meeting as the elucidation of topics at the very foundation of chemical theory: "more precise definition of the concepts of atom, molecule, equivalent, atomicity, alkalinity, and so forth, discussion on the true equivalents of bodies and their formulas; initiation of a plan for a rational nomenclature."

It may seem surprising that as late as 1860 the foremost chemists of the day should meet to discuss such apparently elementary matters. But in fact confusion reigned on these points, most of it arising from confounding of these concepts, from a refusal to accept what we should now call "Avogadro's hypothesis", and from a general sceptical attitude of chemists towards the atomic theory itself. Dalton himself had gone some way towards Avogadro's hypothesis, but used the terms "ultimate particle", atom and molecule, quite indiscriminately. Avogadro's own statement was made in 1811, but it was largely neglected and contrary views were later expressed by the influential Berzelius and Dumas. Atomic weights came to be largely replaced by equivalents. For example, Berzelius had written H_2O for water and had given several correct atomic weights, but under the influence of Gmelin and his famous textbook, the formula HO was in general use in the 1840s together with atomic weights such as C=6, O=8, and so forth. The French chemists Laurent and Gerhardt had attempted a reform of all this, Laurent showing how the use of Avogadro's hypothesis introduced order into the chaos of organic formulae, and Gerhardt returning to many of the correct atomic weights. All these vital matters were therefore sources of controversy in 1860; the hope was that the meeting would clarify and resolve at least some of the basic differences.

Weltzien acted as business manager, made available the buildings of the Technische Hochschule, and gave a short address at the opening of the meeting on the morning of September 3 in the Städenhaus, in which he pointed out the unique nature of the meeting and stressed the importance of the topics to be discussed. After Bunsen had declined, Weltzien was elected to take the chair for the first day.

Kekulé moved that the meeting elect a committee to prepare the topics for discussion, and suggested several of these. The committee was appointed and decided that the meeting should confine itself to the distinction between molecule, atom and equivalent, and the values for atomic weights. According to some reports, particularly that of Mendeleev, a definite conclusion was reached on the second day concerning the first of these matters, and on the idea of equivalent being an empirical concept, independent of that of atom or molecule. But opinions on all the points differed widely and there was no clear-cut decision on the atomic weight question discussed on September 5 and 6. The Italian chemist Cannizzaro gave a celebrated paper in which he stressed the great value of Gerhardt's atomic weights based on Avogadro's theory, and he strongly opposed Dumas' suggestion that these should be used only in organic chemistry whilst the old values were retained in inorganic chemistry.

It seems that the sessions of the meeting were rather diffuse, insufficient organisation of the contributions having been made. One feature of the arrangements may be noted, however. On the evening of the first day, "the members fraternised together at a banquet. . . . This supplementary meeting was by no means the least scientific, the least relished, nor, above all, the least substantial. . . ."

What then did this meeting achieve? At first sight, perhaps not a great deal. Mendeleev, however, clearly felt that progress had been made, that the new ideals were gaining ground: as he put it, "half the chemists have already resolved not to vote against the ideas". There can be no doubt that the clear statements by Cannizzaro had a great influence. Furthermore, reprints of an important paper by Cannizarro written two years earlier were distributed; this was read by Lothar Meyer, who said, "It was as though the scales fell from my eyes, doubt vanished, and was replaced by a feeling of peaceful certainty." Many years later, Mendeleev wrote: ". . . truth, in the form of the law of Avogadro-Gerhardt, received by means of the Congress a wider development, and soon afterwards conquered all minds." So the meeting had a clear significance for the two foremost architects of the periodic system; with this, as with so many subsequent meetings, the indirect consequences were the most important.

"ISOTOPE SHOP" FOR MOSCOW

The first "isotope shop" will be opened shortly on Moscow's Lenin Avenue. It will have a neon sign in Russian, French, and English reading: "Atoms for Peace".

The shop will offer for sale the entire range of radioactive and stable isotopes produced by industry, and also protective materials, equipment, and instruments. It will guarantee prompt delivery of short-lived isotopes.

A demonstration hall will feature the latest achievements in the application of isotopes, provide consultation, and show popular science films. There will be exhibitions on the use of isotopes and penetrating radiations in industry, medicine, and agriculture.

AUSTRALIAN EXPERIMENTAL DAIRY FARM FOR VIET NAM

Cattle and equipment for a dairy research and livestock breeding farm were shipped recently from Sydney, Australia, to Saigon in Viet Nam. They are being installed on an experimental farm already set up thirty-five miles from Saigon, where it is hoped to breed a local dairy herd which will be the nucleus of a dairy industry in Viet Nam.

The farm is part of a long-term project being carried out by the Australian and Viet Namese Governments under the Colombo Plan. The first stage of the

project, the development of pastures, erection of buildings and training of staff, has been completed. In the second stage, 144 head of dairy cattle carefully selected by Australian experts who have been to Viet Nam are being sent to stock the farm.

NEW HYPOTHESIS ON PETROLEUM FORMATION

A hypothesis suggesting that the blue haze seen over the world's vegetated areas is actually petroleum in the process of formation has been advanced by Dr Frits W. Went of the Missouri Botanical Garden, St Louis, Mo., U.S.A.

Writing in the *Proceedings of the National Academy of Sciences* (February 15 issue), Dr Went attributes the blue haze to a layer of asphaltic and bituminous particles created by hundreds of millions of tons of volatile hydrocarbons and near-hydrocarbons expelled into the atmosphere annually by living plants. These particles eventually rain down on earth, and in time, form petroleum.

Dr Went further suggests that these smog-like particles influence the weather in a variety of ways, and also serve to regulate plant growth.

His scientific paper, "Organic Matter in the Atmosphere and its Possible Relation to Petroleum Formation", offers a possible solution to two biochemical mysteries—the fate of plant-produced hydrocarbons and the origin of petroleum.

The volatile organic products that are the subject of Dr Went's paper include terpenes, such as the volatile fraction of turpentine; carotenoids which are plant pigments found in carrots, tomatoes, and colourful autumn leaves; and rubber.

Be U Pu

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Applicants should be University Graduates or A.I.M.

INTERVIEWS will be held at the Queens Hotel, Piccadilly, Manchester on Friday 2nd September from 6 p.m. and on Saturday 3rd September between 9 a.m. and 12 noon. Similar arrangements will be made at Cardiff, Glasgow, Birmingham, and London during September and October. Alternatively interviews can be arranged at Aldermaston. Reasonable travelling expenses will be paid. If you would like to know more, please write for an appointment to . . .

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One of Britain's leading science writers describes

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SPECULATIVE RESEARCH

The first of a series of articles on industrial research specially written for DISCOVERY by

RITCHIE CALDER

Also in the next issue

Psychological Problems in the Antarctic
Continuously Growing Teeth

B.Sc.
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Study at Home

The increasing importance of Science in industry, commerce and education opens up many worth-while opportunities for Science graduates. Wolsey Hall (est. 1894) provides postal tuition for the examinations leading to the B.Sc. degree of London University, for which residence at the University is not required. **Prospectus** (please mention exam or subject) from E. W. Shaw Fletcher, C.B.E., LL.B., Director of Studies, Dept. WM8,

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GENETICIST required to take over the Genetics Section at the Research Institute (Animal Virus Diseases), Pirbright, Surrey. Applicants should have Ph.D. or good Honours Degree with at least two years' post-graduate research experience in microbiology.

The section has been studying the formal genetics of the virus of foot-and-mouth disease including characterisation and selection of markers, measurement of mutation rate, investigation of selective advantage during multiplication in tissue culture, etc., with the object of studying recombination in this virus. The successful applicant will be expected to continue the work broadly along the lines indicated but will have considerable freedom of choice of approach.

NATIONAL PHYSICAL LABORATORY, Teddington, Middx., requires Scientific/Senior Scientific Officers as follows: BASIC PHYSICS DIVISION. Physicist for work on static or dynamic properties of high polymeric materials. Experience of polymer physics desirable. Qualifications: First or Second Class Honours Degree or equivalent. (Ref. A321/OA.) MATHEMATICS DIVISION: Mathematician or Physicist for (*a*) numerical analysis, both application of existing methods and development of new techniques; particularly application thereto of high-speed computers; (*b*) development of high-speed digital computer techniques in various fields. Qualifications: First or Second Class Honours Degree, or equivalent, in Mathematics or Physics. (Ref. A318/OA.) For S.S.O. at least three years' post-graduate experience required. Minimum age 26. Salary ranges (men) S.O. £730–£1205; S.S.O. £1330–£1640. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate Ref. No. Closing date, September 24, 1960.

RESEARCH INSTITUTE (ANIMAL VIRUS DISEASES), Pirbright, Surrey, invites applications for a post in the Biophysics Department at the Institute. Problems undertaken include studies on the structure of viruses, on virus-antibody interaction, and on physical problems relating to dissemination of viruses. The successful applicant would be expected to work in these fields. Qualifications required: Honours Degree in Physics, with interest in application of physical/chemical procedures to macromolecular systems. Appointment in Scientific Officer grade (£690–£1175) or Senior Scientific Officer grade (£1250–£1590), depending on age, experience, and qualifications. House available for married candidate. Superannuation under F.S.S.U. Applications to the Secretary.

RESEARCH INSTITUTE (ANIMAL VIRUS DISEASES), PIRBRIGHT, SURREY, invites applications for vacancy in Biophysics Section to undertake investigation of virus and antibody systems by such methods as electron-microscopy, analytical ultracentrifugation and optical analysis generally. Qualifications: Honours Degree in Physics or Physical Chemistry. Appointment in Scientific Officer Grade (£690–£1175). Suitably qualified candidate would be encouraged to work for higher Degree. Starting salary dependent upon qualifications and experience. Superannuation under F.S.S.U. House available for married applicant. Applications to the Secretary.

PHYSICIST or CHEMIST (male) required by ROYAL MILITARY COLLEGE OF SCIENCE, Shrivenham, Berks., for two or three years' programme of fundamental research (of an academic character and intended for publication) on effects of high-energy radiation on polymers in solutions, and the effect of additives as a means of radiation protection or enhancement. This work would be correlated with corresponding effects in biological systems. Research is supported by D.S.I.R. and directed by the Professor of Physics at the College. Appointment in grade of Scientific Officer. First or Second Class Honours Degree required; experience of polymers or biological systems or ionising radiation desirable. Salary according to experience on scale £690–£1145, with superannuation under F.S.S.U. House available for married man, quarters for single man. Forms from Technical and Scientific Register (K), Ministry of Labour, 26 King Street, London, S.W.1, quoting Order No. A326/OA. Closing date, October 6, 1960.

JUNIOR INFORMATION OFFICER

required by

Atomic Energy Research Establishment

HARWELL

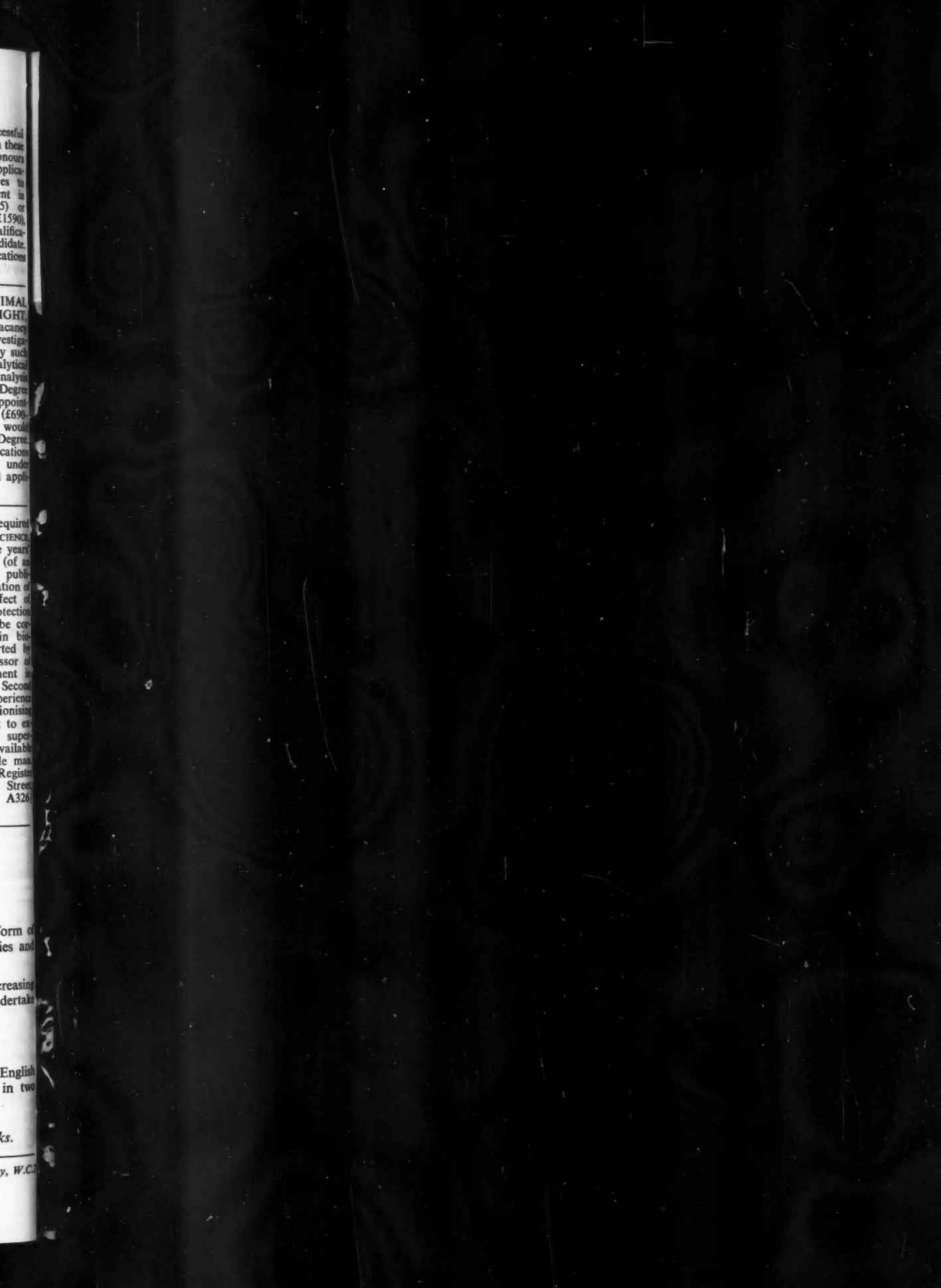
for a team providing a scientific and technical information service in the form of answering technical enquiries, literature searching and preparing bibliographies and abstracting reports.

The person appointed will receive on the job training in order to take increasing responsibility for certain aspects of the work and will be encouraged to undertake further study.

SALARY: £390 (at 18)–£740 p.a.

Women's salary slightly lower at present.

Applicants should have G.C.E. in four subjects at 'O' level including English Language and Mathematics or a Science subject but 'A' level is desirable in two scientific subjects.

Send POSTCARD for details to
Personnel Manager (1765/47), U.K.A.E.A., A.E.R.E., Harwell, Didcot, Berks.

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